Aug. 22, 1944. F. RIEDEL 2,356,533

CONTROL DEVICE FOR ONCE-THROUGH VAPOR GENERATORS

Filed Aug. 27, 1940

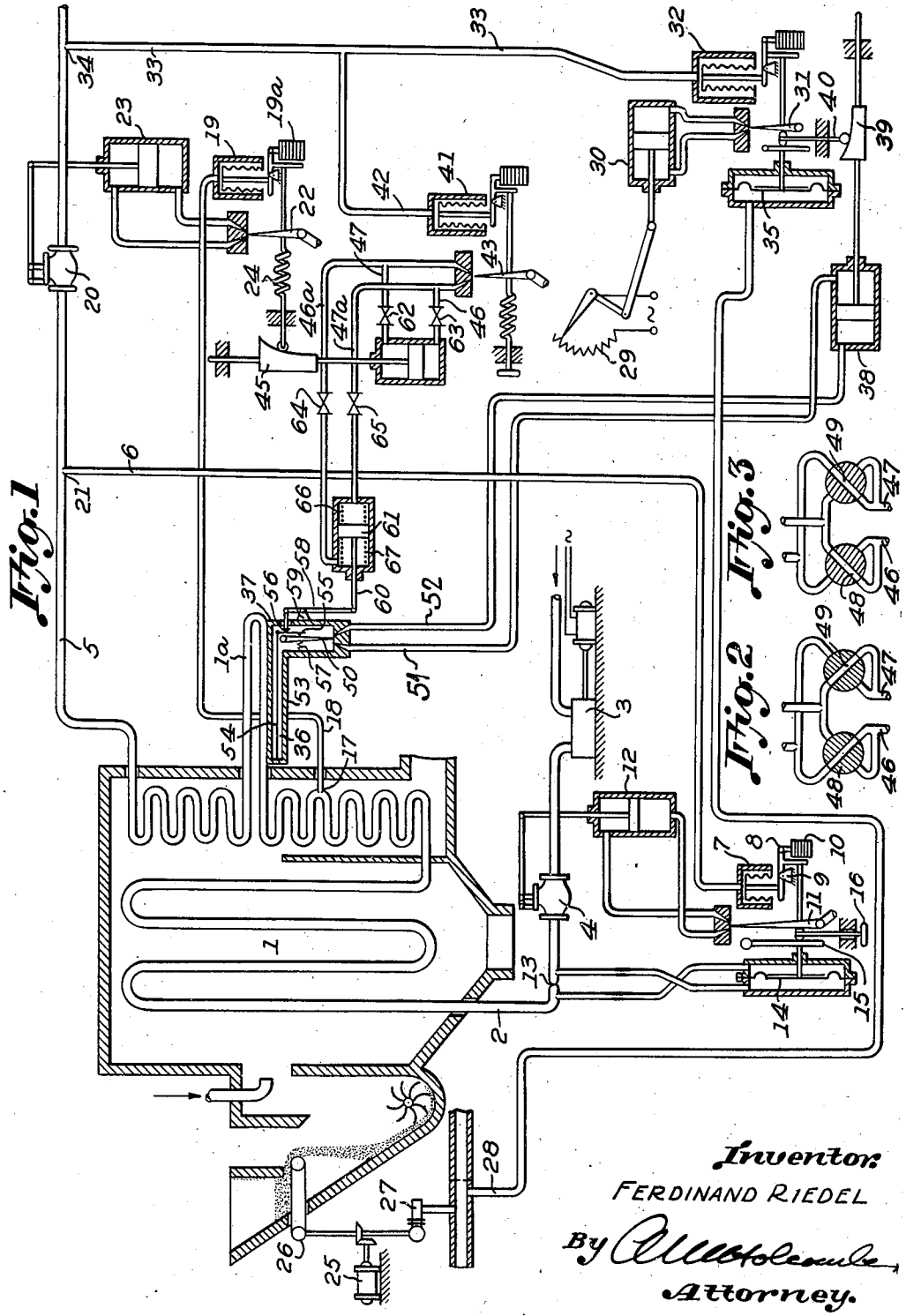


Fig. 1

Fig. 3

Fig. 2

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Patented Aug. 22, 1944

2,356,533

UNITED STATES PATENT OFFICE

2,356,533

CONTROL DEVICE FOR ONCE-THROUGH VAPOR GENERATORS

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Application August 27, 1940, Serial No. 354,449
In Germany June 3, 1939

3 Claims. (Cl. 122—448)

This invention relates to vapor generators of the forced passage type, and more particularly to means for controlling the operation of such vapor generators.

Vapor generators of the forced passage type comprise a once-through vapor passage which receives liquid at one end and delivers superheated vapor at the other end.

In a generator of the forced passage type—in distinction from any other generator type—the evaporation zone is liable to be displaced due to any change in the generator load, it being understood that a decrease results in a displacement of the evaporation zone in the direction toward the superheater section or the output end of the passage, whereby the length of the superheater section will be changed and the temperature of the consumption vapor varied accordingly.

For this reason a previous proposal has been made to provide means for preventing the evaporation zone from undergoing any displacement in the passage.

The present invention is based on the perception that the uncontrolled displacement of the evaporation zone is adapted to be used for controlling the operation of the generator by displacing the evaporation zone at will in accordance with the operating condition of the generator, more particularly in accordance with the generator load.

Such a positive displacement of the zone of evaporation may be advantageous both in the sense of a displacement toward the output end and toward the input end of the passage upon a load increase. The former would be desirable if it is essential to maintain the temperature of the delivered superheated vapor constant whilst the latter would be preferable to enhance the storing capacity of the generator.

In order to more fully explain the subject matter of the invention and its aims and objects reference is had to the accompanying drawing in which

Fig. 1 is a diagrammatic view of a vapor generator of the forced passage type provided with a controlling device according to my invention, and

Figs. 2 and 3 are diagrammatic views showing a reversing device as more fully explained below.

The vapor generator in the usual manner comprises a once-through fluid passage 1 communicating at the input end with a supply conduit 2 supplied by means of a pump 3 and provided with a controlling valve 4 for varying the supply in response to the generator load. To the output end of the passage 1 is connected a main or consumption conduit 5 leading to a consumption apparatus (not shown). A pressure impulse conduit 6 branches off from this conduit 5, the pressure in said impulse conduit varying as a function of the generator load and therefore being adapted to be used as a load impulse for controlling the supply control valve 4. A bellows 7 is acted upon by the pressure in the conduit 6 for controlling a lever 8 swingably mounted at 9 and provided with a counterweight 10. Upon a load increase the weight 10 rocks the lever 8 in clockwise manner so that the jet pipe 11 of a well known Askania jet pipe relay deflects to the left thereby increasing the pressure below the piston of a servomotor 12 operatively connected to the valve 4. Accordingly the valve 4 will be further opened and the flow of the supply and the quantity of feed water are correspondingly increased in response to the increase of the generator load. A restriction 13 in the conduit 2 is provided to create a differential pressure of a feed water quantity impulse acting upon a diaphragm 14 for exerting a restoring action on the jet pipe 11 by means of a well known counter-lever 15 and a ratio slide 16. The increase of the feed water flow due to the opening of the valve 4 results in an increase in pressure on the left side of the diaphragm 14 which leads to an increase in the counter-force restoring the jet pipe 11 to its middle or neutral position shown in Fig. 1.

The water supplied by the conduit 2 to the passage 1 is preheated in the first section thereof and evaporates in the second section. In the range of the evaporation zone 17 a pressure impulse conduit 18 branches off and leads to a bellows 19 for controlling a valve 20 in the main or consumption conduit 5, this valve being arranged beyond the point of communication 21 of the pressure conduit 6 above referred to. The bellows 19 controls a jet pipe 22 by means of a lever system similar to that shown and described in connection with the bellows 7. The jet pipe 22 controls a servo-motor 23, the piston of which is operatively connected to the valve 20 and controls this valve in such a manner that the pressure in the passage at 17, i. e. the evaporation pressure, remains substantially constant. Assuming that, due to the load increase, the pressure at 17 decreases, then the jet pipe 22 will deflect to the left and the piston of the servo-motor 23 will move downwardly thereby further closing the valve 20, so that the pressure at 17 is again increased until the predetermined pressure value to be maintained constant is obtained. This pre-

determined pressure value is represented by a counter-spring 24 acting on the jet pipe 22. Any variation in the initial tension of the spring results in a corresponding variation in the pressure at 17 in the passage.

In the embodiment shown means are provided for likewise controlling the fuel supply in response to the generator. An electric motor 25 is coupled with a conveyor 26 of a well known pulverizer system and with a measuring fan 27 producing, in a conduit 28, a pressure varying in response to the fuel feed. For controlling the fuel feed the motor 25 will be controlled by means of a rheostat 29 inserted in the motor circuit (not shown).

For varying the part of the rheostat inserted in the motor circuit a servo-motor 30 is provided controlled by means of a jet pipe relay 31 together with a bellows 32 acted upon by the pressure in a pressure impulse conduit 33 communicating with the main or consumption conduit 5 as at 34, i. e. beyond the valve 20. Upon a load increase the pressure in the conduit 33 decreases so that the jet pipe 31 deflects to the left and displaces the piston of the servo-motor 30 to the right, thereby decreasing the resistance of the rheostat 29 and increasing the speed of the motor 25. Accordingly the pressure in the conduit 28 increases so that the pressure on the left side of the diaphragm 35 increases and exerts a restoring action on the jet pipe 31 similar to the diaphragm 14 acting on the jet pipe 11.

Beyond the point 17 in the passage a temperature sensitive member 36 is provided for controlling, by means of a relay 37 (the details of which are more fully explained below), a servo-motor 38, the piston of which is connected to a cam 39 for displacing the well known ratio slide 40, by means of which the transmission ratio between 32 and 35 may be varied in a manner well known to anyone familiar with the Askania jet pipe relay. The influence exerted by the temperature sensitive member 36 upon the fuel supply control in dependence on the generator load serves to correct that control for maintaining constant the temperature at 36 in the passage at any generator load.

This temperature has a predetermined relation to the pressure at 17. By maintaining the pressure at 17 in the evaporation zone, i. e. in the zone of saturated vapor, constant, the temperature at this point will be likewise maintained constant and therefore the temperature at 36 should be higher by an amount corresponding to the superheating of the vapor flow from 17 to 36.

Now by maintaining the pressure at 17 constant in the manner described above and by likewise maintaining constant a higher temperature at 36 the evaporation zone is prevented from undergoing any displacement in the passage for the following reason: If, for instance, the evaporation zone is displaced in direction toward the output end, the temperature at 36 will decrease due to the shortening of the superheating path up to 36. Therefore the servo-motor 38 increases the fuel supply to the generator by means of the slide valve 40 until the temperature at 36 again rises to its predetermined value, which is the case as soon as the evaporation zone returns to 17.

As stated above, the initial tension of the spring 24 acting upon the jet pipe 22 represents the value of the pressure to be maintained constant at 17. Accordingly the pressure at 17 may be adjusted by varying the tension of the spring 24. In accordance with the present invention means are provided for varying the tension of the spring 24 so as to displace at will the evaporation zone in response to any operating condition of the generator. In the embodiment shown, the tension of the spring 24 is varied in accordance with the generator load. To this end a bellows 41 is acted upon by the control pressure in the conduit 33, a branch conduit 42 leading from 33 to 41. A jet pipe 43 actuated by the bellows 41 controls a servo-motor 44, the piston of which carries a cam 45, upon which the spring 24 reacts.

This arrangement operates as follows: At a load increase, the impulse pressure in 33, 42 and 41 is reduced, consequently the jet pipe 43 is deflected to the left and the piston of the servo-motor 44 and the cam 45 forced upwardly. Thus the spring 24 is expanded and, provided that a constant pressure exists at 17, i. e. on the bellows 19, the jet pipe 22 is deflected to the left. The valve 20 is closed still further, which results in an increase of pressure at 17 until the equilibrium is re-established between the reduced tension of the spring 24 and the force acting on the jet pipe 22 in the opposite direction, i. e. the force resulting from the difference between the bellows 19 and the weight 19a.

A pressure increase at 17, such as results from an increase in load and temporary closing movement of valve 20, causes a displacement of the evaporation zone toward the output end of the passage 1, as a higher pressure is coordinate with a corresponding higher saturated vapor temperature which only occurs at a point lying a distance between the points 17 and 36 in accordance with the pressure increase at this point.

In this way the length of the superheater section is reduced. This reduction in length does not represent a drawback, on the contrary, at a load increase the rate of the flow of vapor through the superheater section increases correspondingly. This rate increase, however, results in an enhancement of the heating process with the consequence that the temperature of the issuing superheated vapor would increase if the length of the superheating section, i. e. the position of the evaporation zone in the passage, were to remain the same. The reduction in length of the superheater section results in a compensation in the sense of maintaining constant the temperature of the issuing superheated vapor.

A load decrease and consequent opening movement of valve 20 by the control mechanism results in an increase in tension of the spring 24, i. e. a pressure decrease at 17, and hence in a displacement toward the input end of the passage of the evaporation zone, which of course likewise acts in the sense of maintaining constant the temperature of the superheated vapor entering the main or consumption conduit 5.

If it is desirable that a load increase be accompanied by a displacement of the evaporation zone toward the input end, it will only be necessary to exchange the action of the conduits 46, 47 leading from the jet pipe 43 to the servo-motor 44.

For the purpose of a simple reversion of the control of the spring 24, the two pressure fluid conduits 46, 47 may be each provided with a cock 48, 49, respectively, and with additional conduits in the manner shown in Fig. 2. The two cocks are coupled with each other and may easily be reversed from one controlling direction to the other by a single turn.

In the position indicated in Fig. 2 the left re-

ceiving nozzle of the jet pipe 43 is connected to the lower point of connection of the servo-motor 44 and the right receiving nozzle to the upper point of connection. The arrangement according to the invention thus operates in the sense of the temperature of the issuing vapor being maintained constant.

If the two cocks are turned 90° simultaneously, the result is the position shown in Fig. 3 in which the left receiving nozzle of the jet pipe 43 communicates with the upper end of the servo-motor 44 and the right nozzle with the lower end of same. At the same deflecting direction of the jet pipe 43 the controlling direction is thus reversed (which is tantamount to increased storing capacity of the vapor generator).

As will be readily understood, the novel and useful displacement of the evaporation zone can be obtained not only by adjusting the tension of the spring 24, i. e. the value of the pressure at 17, but also by adjusting the value of the temperature at 36 to be maintained constant. In like manner it may be arranged for the pressure value at 17 and the temperature value at 36 to be adjusted in response for instance to the load variation.

The means above described are based on the principle to displace the evaporation zone by varying the pressure to be maintained constant at 17, i. e. the tension of the spring 24. It is, however, likewise possible to displace the evaporation zone by varying the temperature value to be maintained constant, i. e. the temperature at the member 36. To this end the relay 37 must be influenced in the same manner as the relay 22 by varying the initial tension of the spring 24.

The relay 37 comprises a jet pipe 50 the receiving nozzles of which communicate with two conduits 51, 52 leading to the servo-motor 38 for controlling, by means of the cam 39, the ratio slide 40. The temperature sensitive member 36 is shown to be a tube 53 connected to a loop 1*a* of the passage 1, so that the tube 53 assumes the temperature of the loop 1*a*, i. e. the temperature of the vapor. The tube 53 is of a material having a high coefficient of heat expansion. Within the tube there is provided a rod 54 one end of which is fastened to one end of the tube 53 whilst its other end is connected to a lever 55 swingably supported on a knife edge 56 and cooperating with the jet pipe 50. In the opposite direction a spring 57 acts upon the jet pipe as is usual in the well known Askania jet pipe relay.

The knife edge 56 may be displaced in a direction transverse to the lever 55 by means of a link 58 swingably mounted at 59 and operatively connected to the rod 60 of a servo-motor piston 61. This servo-motor belongs to the jet pipe 43, two conduits 46*a*, 47*a* branching off the conduits 46, 47 as shown in Fig. 1.

The conduits 46 and 47 as well as the conduits 46*a* and 47*a* are each provided with a stop valve 62, 63 and 64, 65, respectively in such manner that by closing the valves 64, 65 the evaporation zone will be displaced by varying the initial tension of the spring 24 whilst by closing the valves 62, 63 the evaporation zone will be displaced by varying the temperature value to be maintained constant at 36 in the manner now to be described.

Be it assumed that the evaporation zone shifts, due to an abnormally low load or to the temporary checking action of valve 20 due to a sudden increase in load, in the direction toward the output end of the passage 1. Such a displacement results in a decrease of the temperature at 36 so that, due to a contraction of the tube 53, the lever 55 rocks clockwise thereby deflecting the jet pipe 50 likewise in a clockwise direction and displaces the piston of the servo-motor 38 to the left. In consequence thereof the fuel supply will be decreased until the evaporation zone returns to 17 as described above. The same operation may be obtained by varying the temperature value to be maintained constant in the following manner: As soon as the knife edge 56 is displaced to the right, for instance, the spring 57 deflects the jet pipe in counterclockwise manner, thereby increasing the fuel supply and thus increasing the temperature to be maintained constant at 36. As will be readily understood from the drawing, any displacement of the servo-motor piston 61 results in a displacement of the knife edge 56 corresponding to the variation in the tension of the spring 24 produced by a deflection of the jet pipe 43, which results from any load variation.

If it should be desirable to vary not only the pressure value to be maintained constant at 17 or the temperature value at 36, but both of said values, all the valves 62, 63, 64 and 65 would be opened. In such event I prefer to provide means for a successive operation of the servo-motors 44 and 61 in such a manner that upon a load variation the servo-motor 44 is first put into operation which influences the spring 24, i. e. the pressure to be maintained constant at 17 and subsequently the servo-motor 61, which influences the temperature to be maintained constant at 36. In view of this springs 66 and 67 may be arranged at both sides of the servo-motor piston 61 to retain the piston in its middle position until the servo-motor 44 approaches the end of its stroke.

In another embodiment the springs 66 and 67 may be inserted in the servo-motor 44 so that the servo-motor 61 is put into operation before the servo-motor 44.

For the sake of completeness it may be submitted that it is further possible to use, instead of the springs 66 and 67, any other arrangement according to which the servo-motor, which should operate first automatically controls the valves 62, 63 and 64, 65 of the other servo-motor. The respective valves remain closed until the piston of the servo-motor operating in the first place approaches the end of its stroke. The servo-motor operates by the automatic opening of said valves.

It is to be noted that the desired displacement of the zone of evaporation need not be effected in dependence on the load but may just as well be achieved in response to other operating values as for instance the temperature of the issuing superheated vapor. Control in response to the temperature of superheated vapor would be desirable particularly where the zone of evaporation is to be displaced as a means of preventing fluctuations in the superheated vapor temperature.

The invention is not restricted to the particular embodiment shown and described by way of example only. This embodiment may be modified in a plurality of ways without departing from the spirit of my invention as defined in the appended claims.

What is claimed is:

1. In a device for controlling a vapor generator of the forced passage type having a once-through fluid passage receiving liquid at one end and delivering superheated vapor at the other end, comprising, in combination, pressure controlling means for maintaining a constant pres-

sure in said passage at a point determining the position of the zone of evaporation, temperature controlling means for maintaining a constant temperature in said passage at a point predetermined in relation to said constant pressure point, the temperature to be maintained constant corresponding to the distance from and the position of said constant temperature point in relation to said constant pressure point, means for adjusting the temperature value to be maintained constant, and means for actuating said adjusting means in response to the operating condition of the generator to displace at will the zone of evaporation.

2. In a device for controlling a vapor generator of the forced passage type having a once-through fluid passage receiving liquid at one end and delivering superheated vapor at the other end, comprising, in combination, pressure controlling means for maintaining a constant pressure in said passage at a point determining the position of the zone of evaporation, temperature controlling means for maintaining a constant temperature in said passage at a point predetermined in relation to said constant pressure point, the temperature to be maintained constant corresponding to the distance from and the position of said constant temperature point in relation to said constant pressure point, means for adjusting the pressure value to be maintained constant, means for adjusting the temperature value to be maintained constant, and means responsive to the generator load connected to actuate successively said pressure adjusting means and said temperature adjusting means.

3. In a device for controlling a vapor generator of the forced passage type having a once-through fluid passage receiving liquid at one end, and delivering superheated vapor at the other end, comprising, in combination, pressure controlling means for maintaining a constant pressure in said passage at a point determining the position of the zone of evaporation, temperature controlling means for maintaining a constant temperature in said passage at a point predetermined in relation to said constant pressure point, the temperature to be maintained constant corresponding to the distance from and the position of said constant temperature point in relation to said constant pressure point, means for adjusting the ratio of the constant pressure value and the constant temperature value, means responsive to the generator load connected to actuate said adjusting means for displacing the zone of evaporation in accordance with the generator load variations, and additional means for reversing the adjusting means so that, upon a load increase, the zone of evaporation will be automatically displaced toward the input end and toward the output end of said passage alternately.

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