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F. RIEDEL

CONTROL DEVICE FOR ONCE-THROUGH VAPOR GENERATORS

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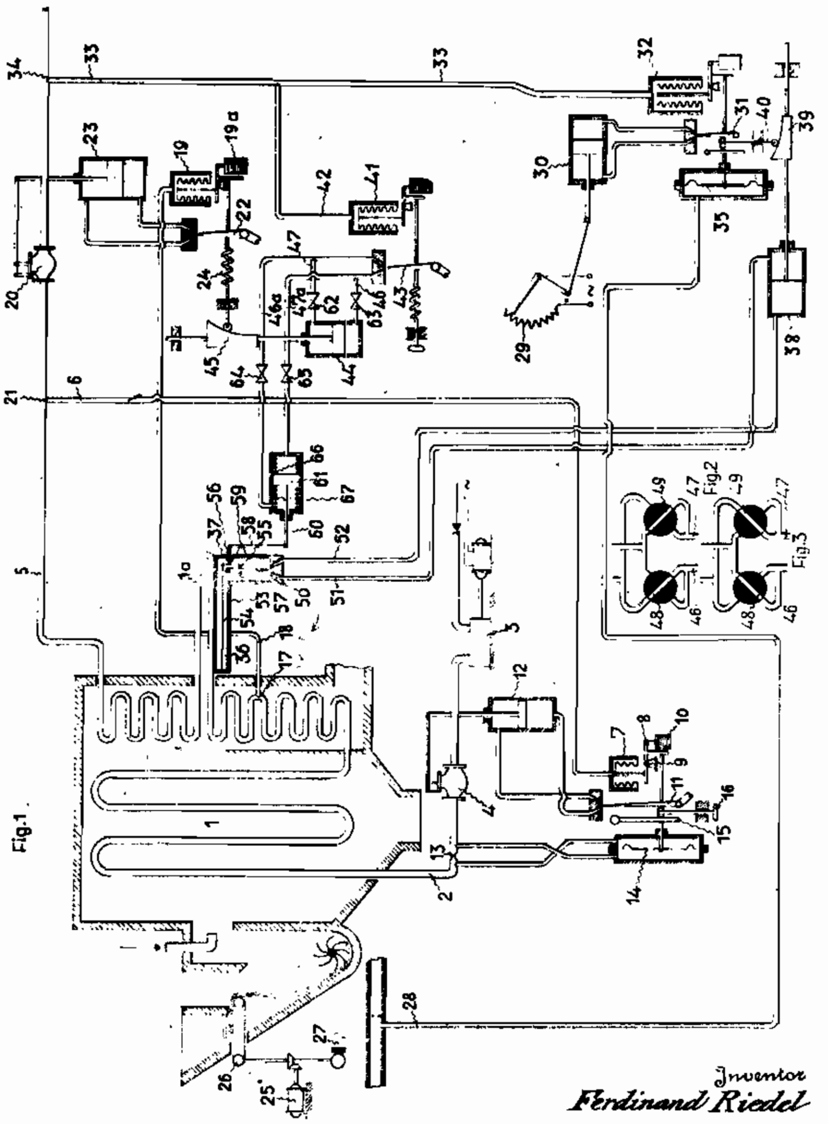

Inventor

Ferdinand Riedel

By A. D. Adams

Attorney

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CONTROL DEVICE FOR ONCE-THROUGH VAPOR GENERATORS

Ferdinand Riedel, Berlin-Mariendorf, Germany; vested in the Alien Property Custodian

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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 receiving liquid at one end and delivering 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 constant the temperature of the delivered superheated vapor 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 show 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 servo-motor 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 correspondingly increased in response to the increase of the generator load. A restriction 13 in the conduit 2 is provided for deriving 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. Be it assumed that due to a 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 predetermined 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 servomotor **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 any one 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 constant the pressure at **17** in the evaporation zone, i. e. in the zone of saturated vapor, 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 constant the pressure at **17** 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** rests.

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 servomotor **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 **19*a***.

A pressure increase at **17** 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 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 super-heated vapor entering the main or consumption conduit **5**.

If in distinction from this embodiment shown in the drawing 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 servomotor **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 receiving 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 simultaneously by 90°, 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 expansion by heat. 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 co-operating 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 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 rod 54 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 clockwise manner, thereby reducing the fuel supply and thus reducing the temperature to be maintained constant at 38. 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 and 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 the springs 66 and 87 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 68 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 is put in action by 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.

FERDINAND RIEDEL.