Dec. 4, 1962 L. E. GRIFFITH 3,066,657

CONTROL OF SUPERHEAT

Filed April 6, 1960 2 Sheets-Sheet 1

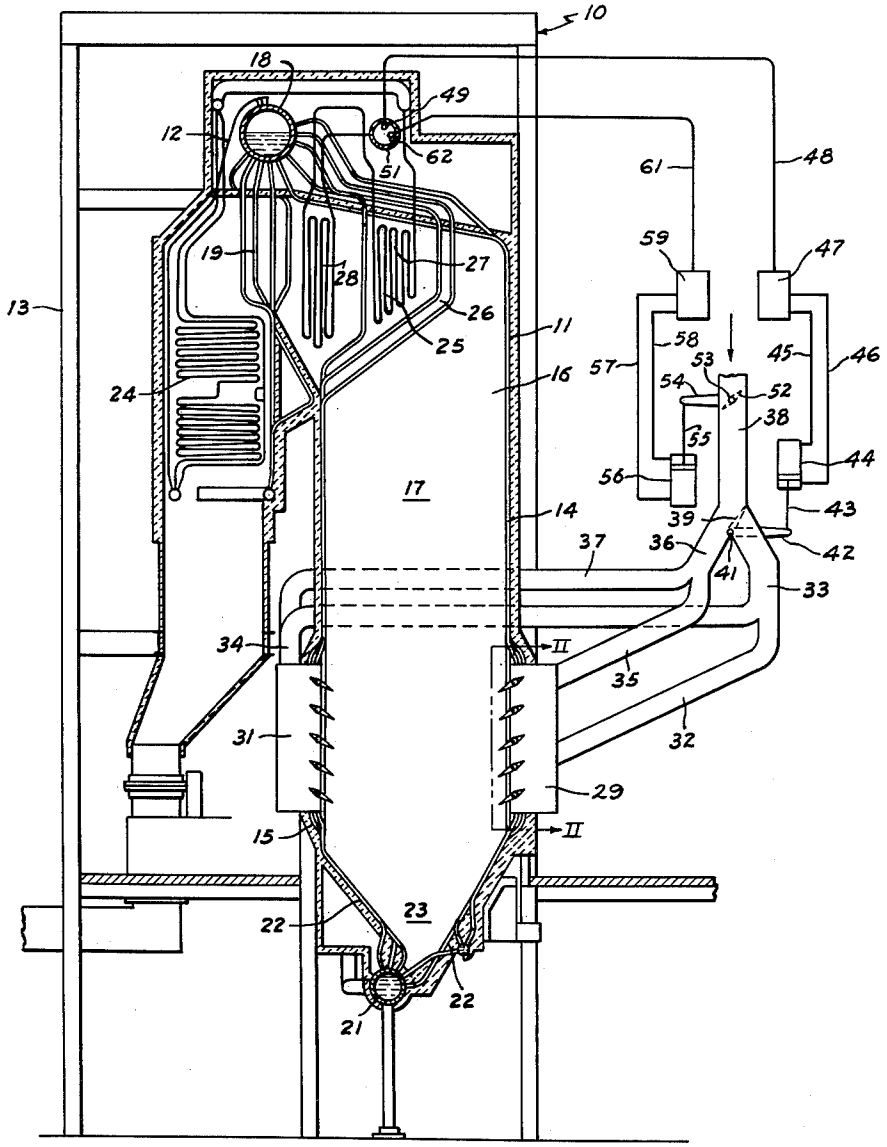

Fig. 1

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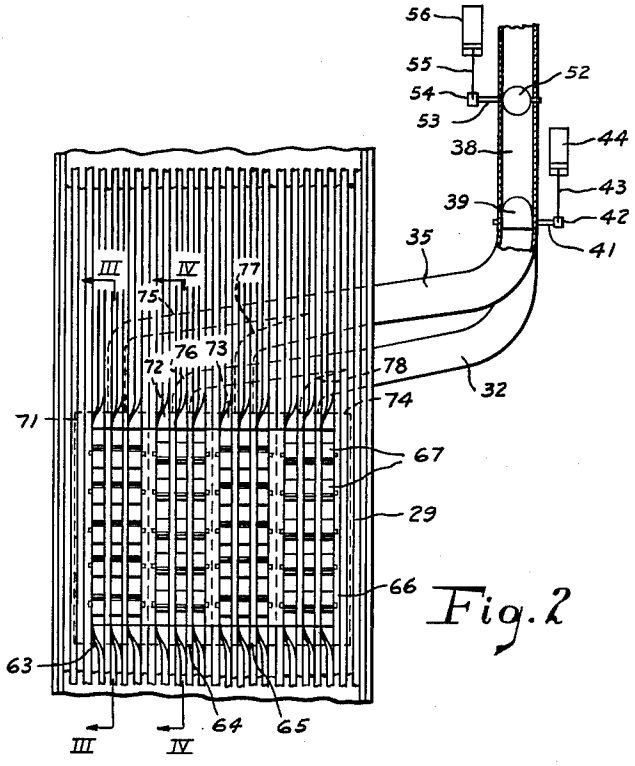

Fig. 2

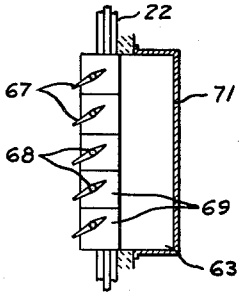

Fig. 3

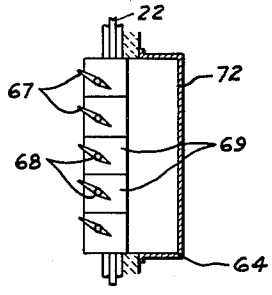

Fig. 4

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3,066,657

CONTROL OF SUPERHEAT

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6 Claims. (Cl. 122—479)

This invention relates to control of superheat and, more particularly, to a method and apparatus arranged to maintain the temperature of superheated steam produced by a steam generating unit at a constant, preselected value. This is a continuation-in-part of patent application Serial Number 584,121, filed May 10, 1956, now abandoned.

In the past, there have been many concepts used in connection with steam generating units to maintain the temperature of the superheated steam at a fixed value irrespective of changes in load on the unit. For instance, the flow of gases over the superheater elements has been controlled by the use of dampers; this practice has the disadvantage of being relatively insensitive and producing relatively high exit gas temperatures at certain loads so that the overall efficiency of the unit is decreased. Superheat temperature has also been controlled by desuperheaters wherein the steam generating unit produces superheated steam at the highest temperature necessary at a reduced load and the steam is cooled to produce the desired steam temperature at highest loads; this has the disadvantage of requiring extremely large superheater elements to take care of adverse conditions. Superheat has been controlled by recirculating a portion of the gases from the back passes of the unit to the furnace proper; this has the disadvantage of producing high dust loading of the furnace gases with resultant cutting and deterioration of the boiler tubes and increase of power requirements. Another method of controlling superheat that has been proposed is the use of a so-called "tilting" burner in which case the flame in the furnace is directed upwardly or downwardly depending on what is necessary to maintain the superheated steam at a constant value; the burners required for this practice are extremely complicated and expensive to build and maintain. Other methods and apparatus for controlling superheat have been suggested which are of lesser importance than those described above but there is no practice which could be said to be perfect since all previously-known methods of controlling superheat suffer from difficulties which render them less than ideal. These deficiencies in the prior art have been obviated by the present invention in a novel manner.

It is therefore an outstanding object of the present invention to provide a method and apparatus for the control of superheat in a steam generating unit in which the method is simple and effective and the apparatus is inexpensive to manufacture and maintain.

Another object of the invention is the provision of an apparatus for the control of superheat whose operation is not detrimental to the efficiency of the steam generating unit.

Another object of the invention is the provision of a method and apparatus for the control of superheat which can be used for initial adjustments of superheat made necessary by inaccuracies in design and construction and is also extremely sensitive in maintaining superheat at constant temperature irrespective of changes in load.

A still further object of the instant invention is the provision of a method and apparatus for the control of superheat in which the mass flow of the steam generating unit is not increased.

Although the novel features which are believed to be characteristic of this invention were particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation and the manner of its organization, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof in which:

FIG. 1 is a longitudinal sectional view of a steam generating unit embodying the principles of the present invention;

FIG. 2 is a somewhat enlarged view of a portion of the apparatus shown in FIG. 1 taken on the lines II—II of FIG. 1;

FIG. 3 is a sectional view taken on the lines III—III of FIG. 2; and

FIG. 4 is a sectional view taken on the lines IV—IV of FIG. 2.

For the purposes of this specification the expression "longitudinal" refers to a direction from the front to the rear of the steam generating unit, i.e., in the plane of FIG. 1, while the expression "transverse" refers to a direction from side to side of the furance, or at right angles to the plane of FIG. 1.

Referring first to FIG. 1, wherein is best shown the general principles of the present invention, a steam generating unit, designated generally by the reference numeral 10, is shown as comprising a furnace 11 and a boiler 12 supported in a structural steel framework 13. The furnace 11 comprises a front wall 14, a rear wall 15, and side walls 16, serving to define a combustion chamber 17. The boiler 12 consists of a steam and water drum 18 having downcomers 19 connecting it to a lower header 21 which serves water wall tubes 22 extending upwardly along the walls of the furnace 11. The header 21 and the water walls 22 serve to form a hopper 23 located in the lower part of the combustion chamber 17 constructed in the manner shown and described in the patent to Balmer No. 2,503,148. The boiler also comprises a primary superheater 24 and a secondary superheater 25. The water wall tubes which extend along the rear wall 15 of the furnace 11 extend across the top of the combustion chamber 17 to form a slag screen 26. The secondary superheater 25 consists of a first portion 27, situated immediately above the combustion chamber 17, and a second section 28 which is placed rearwardly of the rear wall 15 of the furnace, which second section is subject only to convection heat transfer. The first section of the secondary superheater 25 is subject to both radiation from the combustion chamber 17 and convection heat transfer from the gases passing upwardly and rearwardly of the furnace at the upper portion thereof.

A series 29 of burners is mounted in the front wall 14 in the furnace 11, while a series 31 is situated in the rear wall 15. Certain of the burners in the series 29 are connected by a conduit 32 to a conduit 33, while certain of the burners in the series 31 are connected by a conduit 34 to the conduit 33. The remainder of the burners in the series 29 is connected by a conduit 35 to a conduit 36 while certain of the burners in the series 31 are connected by a conduit 37 to the conduit 36. The conduits 33 and 36 are connected through a vertical conduit 38 to a fuel supply, not shown. The conduit 38 is connected with the conduits 37 and 33 by a Y-shaped fixture with the conduits 36 and 33 extending at substantial angles to the centerline of the conduit 38. A dividing vane 39 is situated at the junction of conduits 36 and 33 to conduit 38, and is connected to the fixture by hige pin 41 which permits the vane completely to shut off conduit 36 or conduit 33 alternatively, or to occupy any intermediate position. A crank arm 42 is keyed to the pivot pin 41 for the actuation of the vane. The outer end of the crank arm 42 is connected to the piston rod 43 of a hydraulic linear actuator 44 which is connected by hydraulic lines 45 and 46 to a master control 47. The control 47 is connected by a line 48 to a thermocouple 49 situated in the super-

heated steam header 51 of the boiler. In the conduit 38 somewhat above the connections to the conduits 33 and 36 is situated a flow control valve 52 mounted on a horizontal pivot 53 passing through the center of the conduits. The valve 52 is movable about the hinge pin 53 to either shut off the conduit 38 completely or to open it substantially. Keyed to the pivot pin 53 is a crank arm 54, the outer end of which is connected by hydraulic lines 57 and 58 to a controller 59. The controller is connected by a line 61 to a pressure bulb 62 located in the superheated steam header 51 of the boiler.

FIG. 2 is an elevational view of the series 29 burners as they appear from inside the combustion chamber 17. The series consists of four burners 63, 64, 65 and 66. Each of these burners is of the intertube type shown in the patent application of Craig, Serial No. 299,888, filed July 19, 1952, now Patent No. 2,759,460. For instance, the burner 63, as shown in FIG. 3 consists of a plurality of vanes 67 mounted on pivot pins 68 which pivot pins in turn are mounted in blocks 69 clamped to the water wall boiler tubes 22. The tubes act as supports for the vanes and a great deal of bending of tubes is avoided by this construction. It will be observed from FIG. 3 that the tubes 22 are bent rearwardly in rows of three to form openings for the passage of fuel and air. After initial adjustment, the vanes in burner 63 are directed downwardly and this is true of burner 65 also. On the other hand from FIG. 4 it can be observed that the vanes of burner 64 are directed upwardly and this is also true of burner 66. Burner boxes 71, 72, 73 and 74 are provided for the burners 63, 64, 65 and 66 respectively. The burner box 71 is connected by a conduit 75 to the conduit 35 while the burner box 73 is connected by conduit 76 to the same conduit 35. The burner boxes 72 and 74 are connected by conduits 77 and 78 respectively, to the conduit 32. As is evident in FIG. 2 the vane 39 is curved to fit the walls of the conduit with which it engages on occasion. Furthermore the valve 52 is circular in order that it may completely close off the conduits 38 on occasion. The operation of the invention will be readily understood in view of the above description. Fuel, which may be pulverized coal or gas, passes downwardly past the valve 52 through the conduit 38 and past the vane 39 into the conduits 33 and 36 from which it is distributed to the burners in the series 29 and 31. Air is admitted with the fuel and burns within the combustion chamber 17. The products of combustion pass upwardly through the screen 26 over the superheater 25 and steam is generated in the tubes 22. The steam generated in the boiler is released in the steam and water drum 18 and passes into the primary superheater 24 and from there to the secondary superheater 25, where it is superheated in the first portion 27 and the second portion 28. Both parts of the secondary superheater are subjected to convective heat transfer and, in addition, the first portion 27 is also subjected to radiation from the combustion chamber 17. After passing through the superheater the steam is discharged into the superheated steam header, 51 and from there to the turbine, not shown, whereby electrical energy is produced. It is important that the pressure and temperature of the superheated steam in the header 51 be maintained at constant values irrespective of other conditions in the furnace, particularly changes in load. This is because the turbine is very sensitive to changes in pressure and temperature. Furthermore, if the temperature in the superheater elements is allowed to go too high, there is a strong likelihood of tube failure. In present-day boiler design it is necessary, because of the demand for very high superheated steam temperatures, to use superheated steam temperatures that are very close to the temperature of failure of the alloy metals used in the superheater tubes. Without close control of the superheated steam temperature it is possible that the temperature of failure of the superheater tubes may be exceeded and a disaster may result.

Let us assume that the present apparatus has been tested for operation at 100% load. During the initial operation of the apparatus, the vanes in the burners have been adjusted to give the exact temperature desired in the superheated steam header 51 and then the vanes have been fixed in that position. It will be understood that the flame which originates in the upwardly tilted vane burners, such as burners 63 and 65 of the series 29 residing in the front wall of the furnace, will be tilted upwardly and the gas resulting from these upwardly-tilting burners will reach the superheater at a higher temperature because it has had less opportunity to give off its heat by radiation to the water wall of the furnace. On the other hand, the burners such as burners 64 and 66 which have their vanes tilted downwardly, will produce a flame which is directed toward the bottom of the furnace and the gases leaving these burners and entering the upper parts of the furnace to pass over the superheater, will be relatively cool, since they have traveled along a longer path through the combustion chamber 17 and have had an opportunity to cool by radiation of heat to the water walls of the furnace. Now, when the turbine load drops to a lower level, it will be necessary to permit a smaller amount of steam to pass into the turbine and this is accomplished by a valve in the conduit passing from the header 51 to the turbine. When this valve is closed down for a low load on the turbine, the pressure in the header 51 rises and this change is felt by the gas bulb 62 which lies in that header so that a signal indicative of that rise passes through the line 61 to the controller 59. The controller immediately sends the signal through the hydraulic lines 57 and 58 to the linear actuator 56 which acts upon the crank arm 54 to turn the valve 52 to a position in which less fuel will be permitted to enter the conduit 38. A smaller amount of fuel entering the conduit 38 means that less fuel will be burned in the combustion chamber 17, less steam generated, and the pressure will drop to the desired value. However, in reducing the amount of combustion taking place in the combustion chamber the amount of gases flowing over the superheater elements have also been reduced. This means that the superheated steam entering the header 51 will enter it at a lower temperature. This lower temperature is immediately felt by the thermocouple 49 and a signal passes through the line 48 to the controller 47. The controller 47 sends a signal through the conduits 45 and 46 to the linear actuator 44 so that it reacts through its piston rod 43 and the crank arm 42 to move the vane 39 to another position. The vane will be moved to a position such that the fuel entering the conduit 36 is increased proportionately over that entering the conduit 33. The conduit 36 is connected through the conduits 37 and 35 and the conduits 75, 76 and the like, to the upwardly directed burners of the series 29 and 31. The fuel passing through the conduit 33 and the conduits 32 and 34, which are connected to the downwardly directed burners, will be reduced. This means that the amount of gas leaving the burners which are directed upwardly will be increased, while the amount of gas in the flame leaving the burners which are directed downwardly will be decreased. The net effect is that the temperature of the gases passing over the superheater elements will be increased so that the temperature of the superheated steam entering the header 51 will be increased, thus to compensate for the drop in superheat due to the drop in load. This is the correction which it was desired to make. It will be understood, of course, that the valve 52 will be adjusted to occupy a position permitting the proper amount of fuel to enter the system at any load, the proper amount of fuel being allowed to enter the system in any instance being sufficient to maintain the pressure of steam in the header 51 at a constant value. At the same time the vanes 39 will divide the fuel between the upwardly directed burners and the downwardly directed burners in such a way as to maintain the temperature of the steam in header 51 at a constant value.

It will be readily understood that the present method and apparatus for the control of superheat suffers from none of the deficiencies which are found in prior art practice. For instance, all of the gas originating in the combustion chamber passes over any heat saving devices, such as economizers and air heaters, which are used with the steam generating unit. There is no complicated apparatus that may become fouled with tenacious and corrosive materials which are to be found in a steam generating unit since the only moving elements in the system are the valve 52 and the vane 39 which are elements of a type long recognized in the art and which have been improved until they no longer give trouble in this type of application. Since it is not necessary to desuperheat from a higher temperature, the sizes of the superheaters may be reduced to a minimum and there is no necessity for the use of extremely large amounts of expensive high alloy steel.

While certain novel features of the invention have been shown and described, and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes in the forms and details of the device illustrated, and in its operation, may be made by those skilled in the art without departing from the spirit of the invention.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent is:

1. A method of controlling the temperature of superheated steam in a steam generating unit having a substantial convection superheater and having a vertically-elongated combustion chamber with walls which are lined throughout their heights with steam generating tubes, comprising the steps of adjusting the total amount of fuel introduced into the unit in response to the load on the unit, causing a division of the total fuel into at least a first and a second stream, introducing the first stream of fuel into the unit at an intermediate portion of the combustion chamber in the form of a plurality of third streams in a fixed direction, introducing the second stream of fuel into the unit at an intermediate portion of the combustion chamber in the form of a plurality of fourth streams in a fixed direction which lies at a substantial vertical angle to the direction of and extending downwardly from the direction of the third stream, causing the gases resulting from the third and fourth streams to pass over the superheater, the third and fourth streams being alternately arranged, and adjusting the proportions of the total fuel divided into the first and second streams in response to the temperature of the steam at the steam outlet of the unit, the proportion of fuel in the second stream increasing with increase in load to maintain the temperature of the superheated steam at a preselected value.

2. A method of controlling the temperature of superheated steam in a steam generating unit having a substantial convective superheater and having a vertically-elongated combustion chamber with walls which are lined throughout their heights with steam generating tubes, comprising the steps of adjusting the total amount of fuel introduced into the unit in response to the pressure at the steam outlet of the unit, causing a division of the total fuel into at least a first and a second stream, mixing the streams of fuel with air, introducing the first stream of fuel and air into the unit at an intermediate portion of the combustion chamber in the form of a plurality of third streams at a fixed upwardly-directed angle, introducing the second stream of fuel and air into the unit at an intermediate portion of the combustion chamber in the form of a plurality of fourth streams at a fixed downwardly-directed angle, the third and fourth streams being alternately arranged, causing the gases in the third and fourth streams to pass over the superheater, and adjusting the proportions of the total fuel divided into the first and second streams in response to the temperature of the steam at the steam outlet of the unit, the proportion of fuel and air in the second stream increasing with increase of load to maintain the temperature of the superheated stream at a preselected value.

3. A method of controlling the temperature of superheated stream in a steam generating unit having a vertically-elongated furnace with walls which are lined throughout their heights with steam generating tubes and with a gas exit at the upper end, the unit having a substantial convection superheater, comprising the steps of increasing and decreasing the total amount of fuel introduced into the unit in response to decreases and increases respectively in the load on the unit to maintain the steam pressure constant, causing a division of the total fuel into at least a first and a second stream, mixing the streams of fuel with air, introducing the first stream of fuel and air into the unit at an intermediate part of the furnace in the form of a plurality of third streams in a fixed direction, introducing the second stream of fuel and air into the unit at an intermediate part of the furnace in the form of a plurality of fourth streams in a fixed direction which lies at a substantial vertical angle to and downwardly from the direction of the first stream, the third and fourth streams being alternately arranged, causing the gases in the third and fourth streams to pass over the superheater, and the total fuel passing into the said first stream increasing and decreasing in response to decreases and increases respectively in the temperature of the steam at the steam outlet of the unit to maintain the temperature at a constant preselected value.

4. Apparatus for controlling superheat in a steam generating unit having a substantial convection superheater and having a vertically-elongated combustion chamber with walls which are lined throughout their heights with steam generating tubes, comprising a series of first burners located at an intermediate portion of the combustion chamber and each adapted to direct a flame downwardly of the unit, a series of second burners located at an intermediate portion of the combustion chamber and each adapted to direct a flame upwardly of the unit, the first and second burners being alternately arranged, a gas passage into which the gases from the burners are directed and in which the superheater resides, means increasing and decreasing the total amount of fuel passing through the burners in response to decrease and increase respectively in the pressure at the steam outlet of the unit, and means responsive to the temperature of the steam at the steam outlet of the unit to divide the total amount of the fuel between the two series of burners, the amount of fuel received by the series of second burners increasing and decreasing with an increase or decrease respectively in the load on the unit to maintain the temperature of the superheated steam at a preselected value.

5. Apparatus for controlling superheat in a steam generating unit having a vertically-elongated furnace with walls which are lined throughout their heights with steam generating tubes and with a gas exit at the upper end, the unit having a substantial convection superheater, comprising a series of first burners located at an intermediate portion of the furnace and each adapted to direct the flame in a fixed direction, a series of second burners located at an intermediate portion of the furnace and each adapted to direct the flame in a direction lying at a substantial vertical angle to the direction of the flame from the first burners, the first and second burners being alternatively arranged, a gas passage into which the gases from the burners are directed and in which the superheater resides, means increasing and decreasing the total amount of fuel passing through the burners in response to increase or decrease respectively in the load, and means responsive to the temperature of the steam at the steam outlet of the unit to divide the total amount of fuel between the two series of burners to maintain the steam temperature at a constant preselected value, the amount of fuel received by the series of second burners increas-

ing and decreasing with an increase or decrease respectively in load on the unit.

6. Apparatus for controlling superheat in a steam generating unit having a vertically-elongated furnace with front, rear, and side walls which are lined throughout their heights with steam generating tubes and with a gas exit at the upper end, the unit having a substantial convection superheater, comprising a series of first intertube burners located in opposed relationship at an intermediate portion of the front and rear walls of the furnace and each having a set of vanes adapted to direct the flame at a fixed angle to the horizontal, a series of second intertube burners located in opposed relationship at an intermediate portion of the front and rear walls of the furnace and each having a set of vanes adapted to direct the flame in a direction lying at a substantial vertical angle to the direction of the flame from the first burners, the first

and second burners being alternately arranged, a gas passage into which the gases from the burners are directed and in which the superheater resides, means increasing and decreasing the total amount of fuel passing through the burners in response to increase or decrease respectively in the load, and means responsive to the temperature of the steam at the steam outlet of the unit to divide the total amount of fuel between the two series of burners to maintain the steam temperature at a constant preselected value, the amount of fuel received by the series of second burners increasing and decreasing with an increase or decrease respectively in load on the unit.

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