

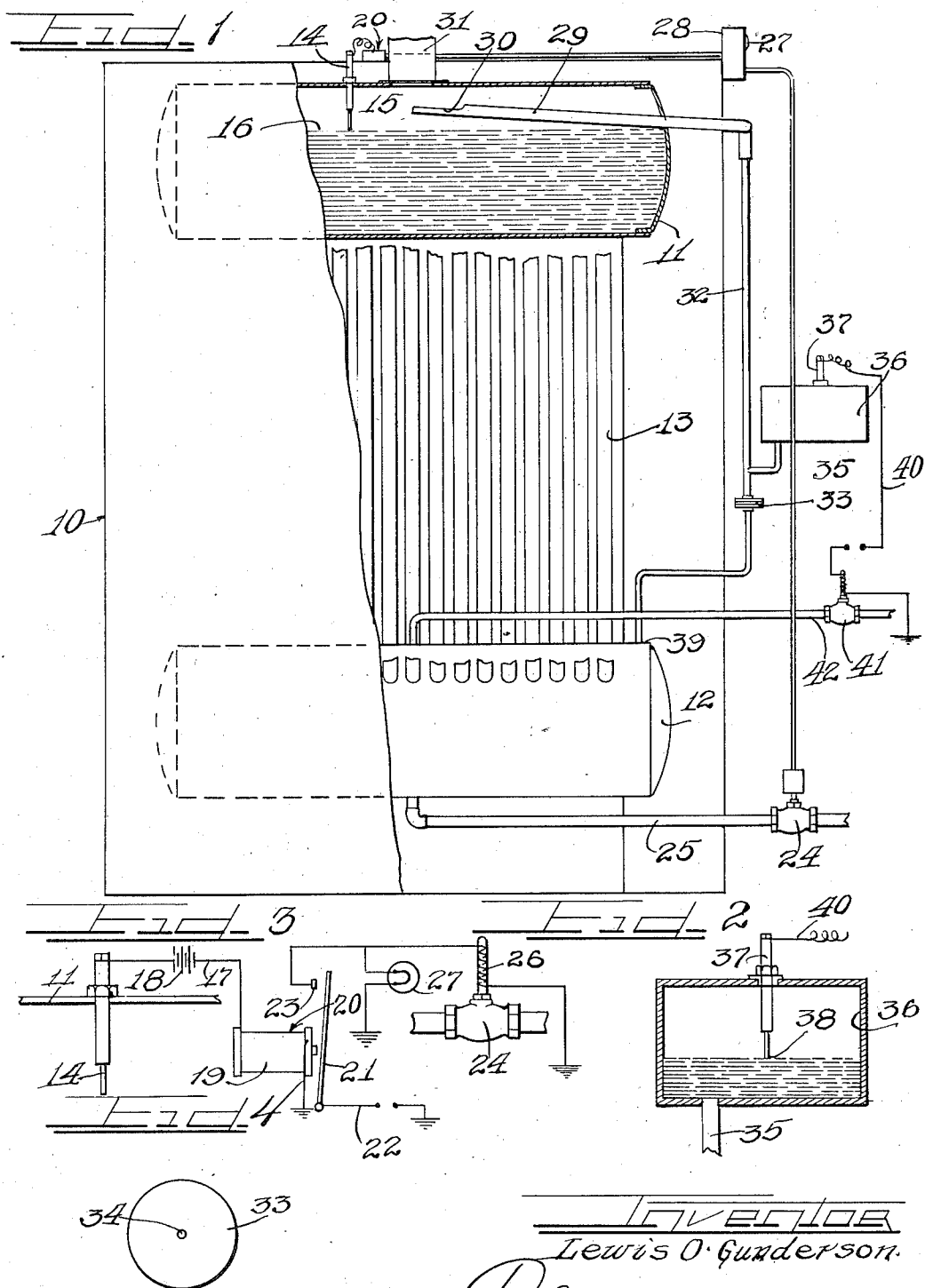
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METHOD OF PREVENTING MOISTURE ENTRAINMENT IN STEAM BOILERS

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METHOD OF PREVENTING MOISTURE
ENTRAINMENT IN STEAM BOILERS

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This invention relates to a method of preventing the entrainment of moisture in steam withdrawn from a boiler for useful purposes.

One of the major problems in steam boiler use is the prevention of the carrying off of water and moisture in the steam withdrawn from boilers for use in operating turbines, steam engines and the like. With the advance in the design of boilers, improvements have been made in boiler construction with a view to lessening this trouble. Despite the many refinements in construction, the problem still remains.

Steam engineers and technical men connected with this field have not agreed among themselves as to the cause for the entrainment of moisture or water particles with the steam. Recommendations for overcoming the trouble are of a varying nature. As they do not agree on the cause, the cure for the problem is remote.

It is known that the use of very impure water causes excessive foaming with consequent trouble due to the carrying over of the foam particles with the steam. It would seem from this that the use of pure water would obviate the difficulty. But this is not true. In experimenting with high pressure steam using comparatively pure water, that is, water having a very low concentration of dissolved salts, I have observed that bubbles rising through the liquid burst immediately upon reaching the surface, projecting the droplets of water into the steam space in the form of mist.

Through these observations, I have discovered that the bursting of the bubbles, the formation of the mist and the entrainment of moisture in the steam is due primarily to the surface characteristics of the boiling water. An increase in the surface tension results in a proportionate increase in the amount of moisture in the steam. It follows that a decrease in the surface tension causes a decrease in the moisture entrained in the steam.

It is therefore the prime object of this invention to decrease the amount of moisture carried over with the steam by decreasing the surface tension of the water in the boiler, and especially by adding a chemical to the boiler water to cause the formation of a foam blanket of reduced surface tension.

The fact that a blanket of foam rests on the water surface is no assurance that effervescence and subsequent entrainment of water will not occur, because the films of the foam may have high surface tension under certain conditions, although most generally boiler water foam is of low surface tension characteristics. I have had

considerable actual experience with locomotive boilers wherein severe effervescence or moisture entrainment with the steam occurred coincidental with a blanket of foam on the water surface, and a considerable concentration of dissolved solids in the boiler water, which latter concentrations in one set of observations, were in the neighborhood of 3000 parts per million of alkali salts. The alkali salt content of this boiler water would tend to produce a foam of low surface tension characteristics, but the chemicals added with a proprietary boiler compound used, changed the foam characteristics to produce one of high surface tension, resulting in effervescence above the foam level. This condition would greatly increase the entrainment of moisture with the steam, by bringing the bursting bubbles into closer proximity to the steam outlet.

However, by adding my chemical to the boiler water, the chemical will quickly find its way to the surface of the foam and be adsorbed therein, lowering the surface tension of the foam bubble films and thus preventing effervescence.

It is a further object of this invention to provide a method for controlling the moisture content of steam in a high pressure boiler.

Another object of this invention is to produce high quality steam without the aid of superheaters to dry the steam.

It is a particular object of this invention to provide a method of introducing a substance into a boiler to advantageously affect the surface characteristics of the water therein.

It is a further particular object of this invention to provide a method of automatically introducing a substance into a boiler so as to advantageously affect the surface characteristics of the foam therein, in accordance with the condition of the boiler.

It is a further important object of this invention to provide a combination of means for controlling the operation of a steam boiler and prevent moisture entrainment in the steam, one of the means being automatically operative to introduce into the boiler a chemical capable of reducing the surface tension of the boiler water so as to produce a blanket of foam on the boiler water and the other being automatically operative to blow the boiler when the foam level becomes excessively high.

Other and further important objects of this invention will become apparent from the drawing taken in consideration with the following specification.

On the drawing:

Figure 1 is a side elevational view of a boiler with parts broken away and in section to illustrate the installation of equipment embodying the principles of this invention.

Figure 2 is a detail sectional view of an electrode chamber.

Figure 3 is a wiring diagram.

Figure 4 is an enlarged detail view of the orificed plate.

As shown on the drawing:

The reference numeral 10 indicates more or less diagrammatically a boiler setting in which are mounted an upper boiler drum 11 and a lower boiler drum 12 with the usual steam tubes 13 extending in banks between said boiler drums. The boiler itself is of a conventional design and forms no part of my present invention but serves merely for purposes of illustration. Other types of boilers may obviously be used.

According to my present invention, the upper drum 11 is provided with an electrode 14 that extends through the shell of the drum and insulated therefrom into the steam space 15 above the level 16 of the water and foam therein. Said electrode 14 is included within a circuit, as indicated in Fig. 3, that comprises a wire 17, a battery 18, and a solenoid 19. One end of the wire 17 is connected to the outer end of the electrode 14 and the other end is grounded, as to the shell of the boiler 11. The body of water and foam within the upper boiler 11 therefore serves to close the circuit when the foam or water level 16 contacts the lower extremity of the electrode 14.

Said solenoid 19 forms a part of a relay indicated generally by the reference numeral 20, the armature 21 of which is included in a power circuit 22. Said armature 21 is adapted to close said circuit 22 by contact with a contact point 23, when the foam or water level 16 closes the electrode circuit. When the power circuit 22 is closed, a blow-off valve 24 is automatically opened in the blow-off line 25 from the lower boiler drum 12. Any suitable type of electrical device, indicated generally at 26, may be used to operate the blow-off valve 24 upon energization of the power circuit 22.

As a visible signal to indicate the height of the foam or water level 16 in the upper drum 11, a lamp 27 is inserted in parallel in the battery circuit 22. Said lamp 27 may be enclosed within a suitable housing 28, or cabinet, located within sight of the boiler operator.

The upper drum 11 is also provided with a moisture collecting means which comprises a pipe 29 extending in an inclined position into the steam space 15 above the normal water level. The end of said pipe 29 is preferably cut away along its upper side, as at 30, to provide a collecting lip into which moisture or foam may be deposited. The open lip 30 is preferably positioned directly beneath the main steam pipe 31 leading from the top of the boiler 11. In this way, if there are any moisture or liquid particles entrained in the steam that is being withdrawn through the pipe 31, such particles will gradually collect in the lip 30 of the pipe 29 and flow out through said pipe into a vertical conduit 32.

Said piping 32 is provided with an orificed plate 33 having a restricted orifice 34. Above said plate 33 there is a branch connection 35 leading to an electrode chamber 36. An insulated electrode 37 extends into said chamber 36 and terminates, as

at 38 at a point slightly above the bottom wall of the chamber 36.

Beyond the orificed plate 33, the piping 32 extends into the top of the lower drum 12, as at 39. The electrode 37 is connected in a power circuit 40 to an electrically operated valve 41 in a pipe line 42 leading into the top of the lower drum 12. Said pipe 42 leads from a supply of a chemical capable of reducing the surface tension of the water in the boiler when introduced therein.

In operation, when the amount of liquid collected in the pipe 29 and piping 32 is being accumulated at a rate greater than can flow through the orifice 34, some of the liquid backs up into the electrode chamber 36 through the pipe 35. Depending upon the size of the orifice 34 and the positioning of the electrode 37 within said chamber 36, the system may be adjusted to close the electrode circuit 40 at such times as the moisture content of the steam warrants the addition of a surface tension reducing substance into the boiler.

When the circuit 40, including the electrode 37 in the chamber 36, is closed or energized to inject into the boiler a chemical capable of reducing the surface tension of the boiler water, the chemical is introduced through the pipe 42 into the lower boiler drum 12, preferably at the upper part of the lower drum as shown. The chemical is caught up in the general circulation and distributed through the circulating boiler water passing through the tubes 13.

The apparatus described above is adapted particularly for the feeding of a substance to the boiler to control the surface characteristics of the water therein, but in addition thereto, provides for the blowing off of the boiler when the foam or water level is too high. In operation, the electrode 14 extends to within a few inches of the normal water level, but when the water or foam level rises to contact the lower end of the electrode 14, the electrode circuit is closed, the light 27 flashes a warning to the engineer, and the blow-off valve 24 is opened to lower the level within the boiler.

In carrying out the process of this invention with respect to the decreasing of the boiler water surface tension to form a blanket of low surface tension foam thereon within the boiler, any substance may be used which has the effect of reducing the surface tension of the water or foam. Such substances are positively adsorbed in the steam bubble liquid interfaces, or in the bubble film on the surface of the water, thereby reducing the surface energy or surface tension thereof. The addition of these substances successfully prevents, almost entirely, the projection of liquid droplets into the steam space and thus prevents entrainment of moisture with the steam.

It is desirable to use a chemical or substance of a stable nature that will not readily react with the boiler water constituents to form other compounds ineffective in maintaining a low surface tension condition. The chemical to be preferred should not be decomposed at boiler water temperature but should be stable. In fact, the substance should, if possible, be inert to chemical reaction under the conditions obtaining so that it is free to physically change the condition of the boiler water and produce a lasting effect.

The soaps of the fatty acids bring about satisfactory results, but their effect is more or less temporary, especially in boiler waters that con-

tain calcium and magnesium salts in solution, since these salts will combine with the soaps to form insoluble compounds of calcium or magnesium, thus destroying the soaps. The net result of this is that the soap must frequently be replenished but if too much soap is required, the compounds formed in the boiler, due to the reaction between the soap and the ingredients of the boiler water, will be objectionable.

Certain other substances have the advantages mentioned above in connection with soaps of fatty acids, but do not have the disadvantages therein mentioned.

A naturally occurring product, humus, as well as the substance saponin have been used with considerable success. These substances tend directly to break down the film strength of the water, to prevent the excessive bursting strength of bubbles and therefore prevent effervescing of the boiler water which causes the dangers hereinbefore mentioned. They may be injected into the boiler in water solution by means of the above described apparatus.

The class of chemical compounds which I have found best suited for bringing about the reduction of surface tension of the boiler water, without causing objectionable secondary reaction, include the water soluble sulfuric esters of higher fatty alcohols, or the compounds produced by hydrogenating higher fatty acids to produce higher fatty alcohols and then forming sulfuric acid derivatives of these fatty acids (cf. Industrial and Engineering Chemistry, vol. 25, No. 2, Feb. 1933, p. 138). The sodium salts of the sulfuric esters of these higher alcohols have all the advantages of ordinary soaps without their disadvantages.

While calcium and magnesium salts will precipitate out ordinary soaps from solution, they will not do so in the case of the sulfuric acid esters of these higher alcohols. The magnesium and calcium salts of these compounds are soluble and retain the properties that tend to lower the surface tension of the water, thus preventing effervescence at the water surface. The amount of chemical needed to bring about the desired result will naturally vary with certain operating conditions and also with the nature of the boiler feed water used. I have found that as little as 10 parts per million of the sodium salt of the sulfuric esters of the higher fatty alcohols maintained in the boiler water are sufficient to prevent entrainment in boilers operating under ordinary rating, but the average concentration of this chemical in the boiler water appears to approximate 25 parts per million. The correct amount of chemical that will be needed to prevent effervescence or excessive moisture in the steam is automatically regulated and maintained by the apparatus described above.

I am aware that many changes may be made and numerous details of construction may be varied through a wide range without departing from the principles of this invention, and I, therefore, do not purpose limiting the patent granted hereon otherwise than necessitated by the prior art.

I claim as my invention:

1. The method of reducing the entrainment of moisture in the steam from boilers using effervescing water, which comprises introducing a substance into the boiler to reduce the surface tension of the water therein and controlling the introduction of said substance by the accumula-

tion of liquid from the moisture entrained in the steam from said boiler.

2. The method of reducing the entrainment of moisture in the steam from boilers using water of effervescing character, which comprises introducing a substance therein which reduces the surface tension of said water and controlling the amount of substance so introduced by the amount of moisture entrained in the steam from said boiler.

3. The method of preventing the entrainment of moisture in steam from boilers using water of effervescing character, which comprises introducing a sulfuric acid ester of higher molecular weight alcohols into the boiler water to produce a blanket of foam thereon and controlling the amount of compound so introduced by the amount of moisture entrained in the steam from said boiler.

4. The method of preventing the entrainment of moisture in steam from boilers using water of effervescing character, which comprises introducing a sodium salt of a sulfuric acid ester of higher molecular weight alcohols into the boiler water to decrease surface tension therein and controlling the amount of compound so introduced by the amount of moisture entrained in the steam from said boiler.

5. In combination with a boiler, means connected to said boiler for injecting a surface tension reducing substance therein and electrical means responsive to the condition of the steam in said boiler for operating said first means.

6. The method of reducing the entrainment of moisture in steam in boilers using water of effervescent character, which comprises introducing a sulfuric ester of a higher fatty alcohol into the boiler water to reduce the surface tension thereof and controlling the amount of the chemical so introduced in accordance with the moisture content of the steam in the boiler.

7. The method of reducing the entrainment of moisture in steam of boilers using water which produces a foam within the boiler of high surface tension characteristics, resulting in effervescence and moisture entrainment in the steam, which comprises adding to the boiler water a surface tension reducing substance that does not form an insoluble precipitate with calcium and magnesium salts therein.

8. The method of preventing the entrainment of moisture in steam which comprises introducing humus into the boiler water to reduce the surface tension thereof and controlling the amount of humus so introduced by the amount of moisture entrained in the steam from said boiler.

9. The method of preventing the entrainment of moisture in steam which comprises introducing saponin into the boiler water to reduce the surface tension thereof and controlling the amount of saponin so introduced by the amount of moisture entrained in the steam from said boiler.

10. The method of reducing the entrainment of moisture and impurities in steam generated from boiler water in steam generators which comprises adding a surface tension reducing substance to said boiler water that is adsorbed in the liquid surfaces of the boiler water.

11. The method of reducing the entrainment of moisture and impurities in steam from boilers using effervescent water which comprises introducing a surface tension reducing substance into said water that will accumulate in the liquid sur-

face of the water, thereby displacing undesirable impurities and at the same time reducing the surface tension of said liquid surfaces.

12. The method of reducing the entrainment of impurities in steam from boilers having boiler water therein which comprises introducing a surface tension reducing substance into the boiler water that will find its way to the surfaces of said water and displace undesirable impurities therein.

13. The method of reducing the entrainment of moisture in steam produced in boilers using substantially pure water which comprises adding, in controlled amounts, a substance to the boiler water which reduces its surface tension to thereby prevent effervescence from the water surface.

14. The method of reducing the entrainment of moisture in steam which comprises adding regulated amounts of a surface tension reducing agent to the boiler water for controllably reducing the surface tension of the water in the steam boiler just sufficient to prevent effervescence from the water surface.

15. The method for reducing the entrainment of moisture in steam boilers using water of effervescing character which produces an effervescent foam, comprising feeding a surface tension reducing substance to the boiler for reducing the surface tension of the water and of the foam therein and controlling the amount of said substance so introduced by the amount of moisture entrained in the steam from said boiler.

16. In combination with a steam boiler, a moisture collecting tube in the steam space of the boiler, a pipe line for draining said tube, a dis-

charge orifice in said pipe line, a water collecting chamber in communication with said pipe above said orifice adapted to receive moisture flowing thru said pipe in excess of the draining capacity of said orifice, a second pipe line for feeding a surface tension reducing substance to said boiler, a valve in said second pipe line and means actuated by the water level in said chamber to open and close said valve.

17. In combination with a steam boiler having an upper boiler drum and a lower boiler drum connected by a plurality of steam tubes, a moisture collecting tube in the steam space in said upper drum, a pipe line for draining said tube into said lower drum, a discharge orifice in said pipe line, a water collecting tank communicating with said pipe line above the orifice therein for receiving water from said pipe in excess of the capacity of said orifice, an electrode in said tank, a second pipe line for feeding foam forming substances to said boiler, an electrically operated valve in said second pipe line, and an electric circuit including said valve and said electrode whereby said valve is opened when the circuit is closed by the water in the tank contacting the electrode.

18. The method of reducing the entrainment of moisture in steam produced in boilers using effervescing water, which comprises adding a surface tension reducing agent to advantageously affect the surface characteristics of the boiler water and prevent violent bursting of steam bubbles causing a spray of water droplets into the steam space of the boiler.

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