Feb. 1, 1944. L. O. GUNDERSON ET AL 2,340,468

BOILER WATER CONDITIONER AND BLOW-OFF SYSTEM

Filed Dec. 4, 1941 3 Sheets-Sheet 1

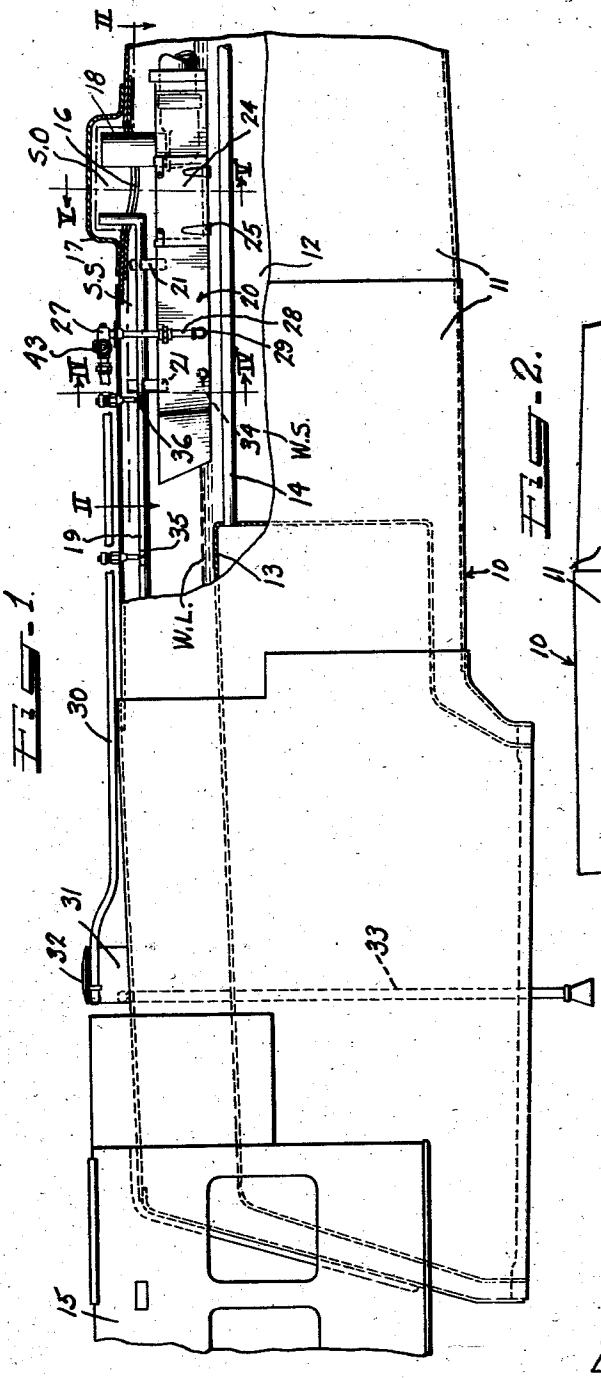

Fig. 1.

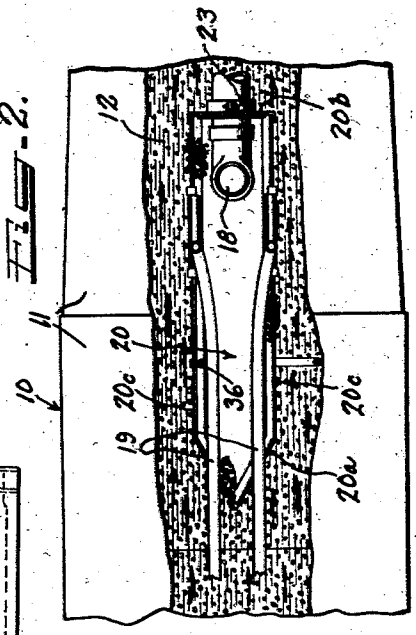

Fig. 2.

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BOILER WATER CONDITIONER AND BLOW-OFF SYSTEM

Filed Dec. 4, 1941 3 Sheets-Sheet 2

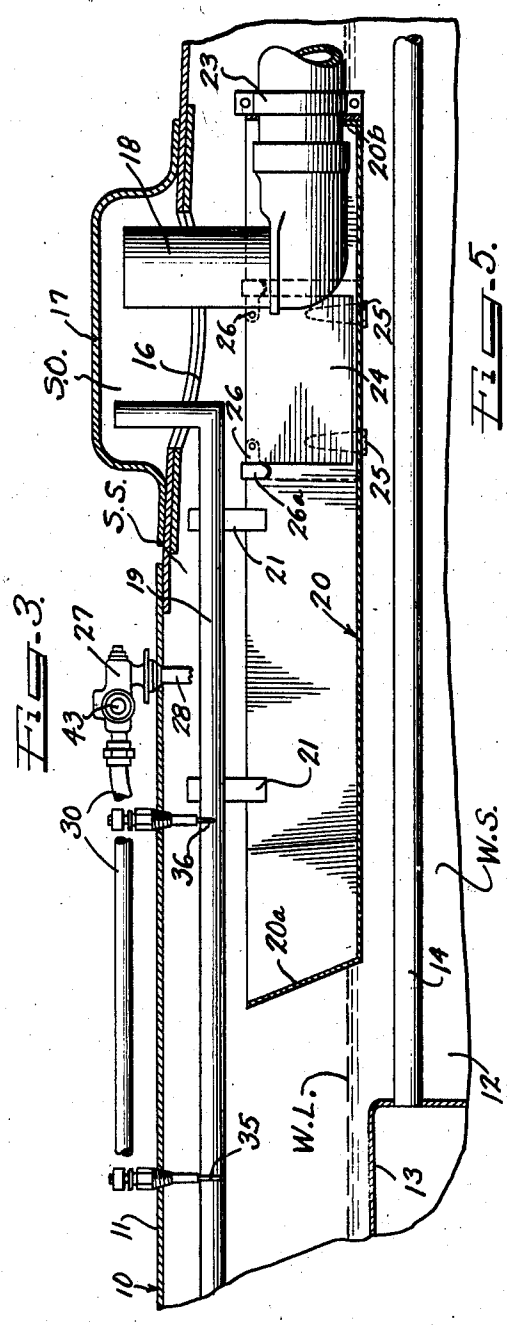

Fig-3.

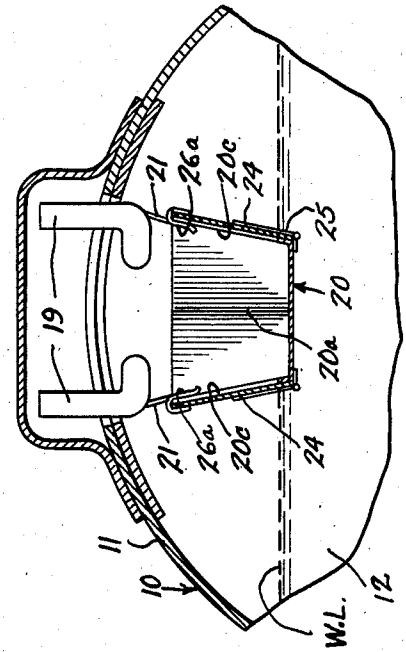

Fig-5.

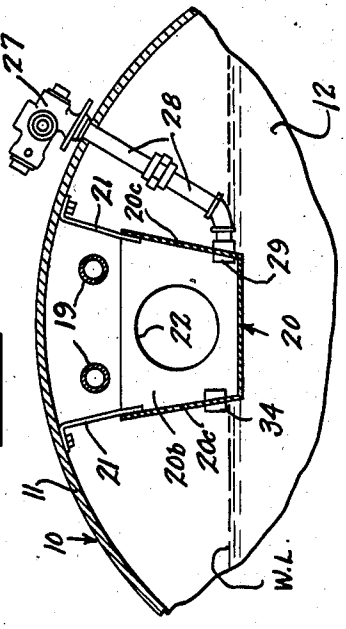

Fig-4.

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BOILER WATER CONDITIONER AND BLOW-OFF SYSTEM

Filed Dec. 4, 1941 3 Sheets-Sheet 3

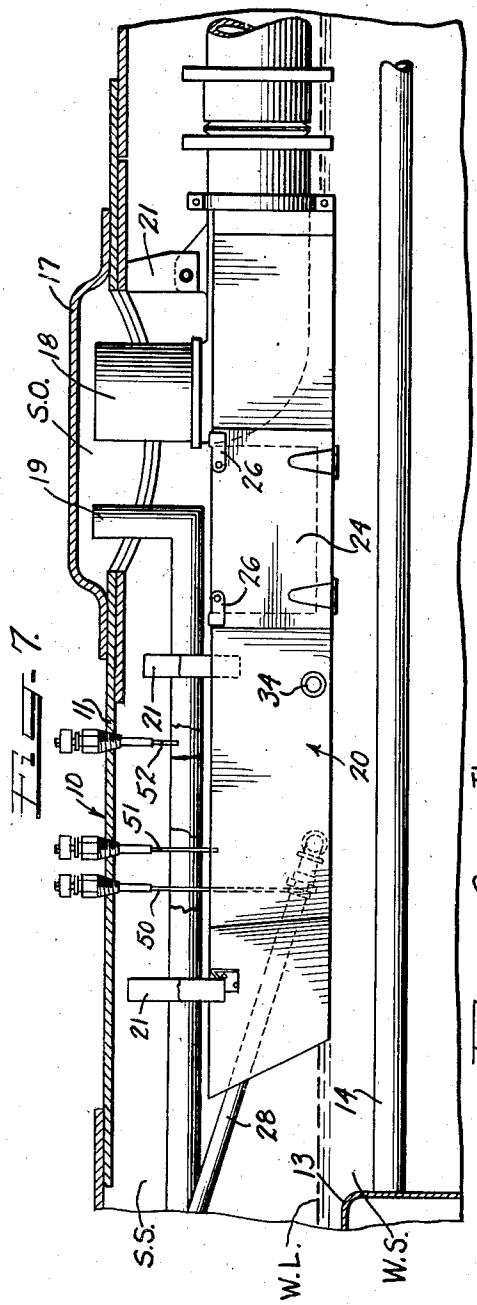

Fig. 7.

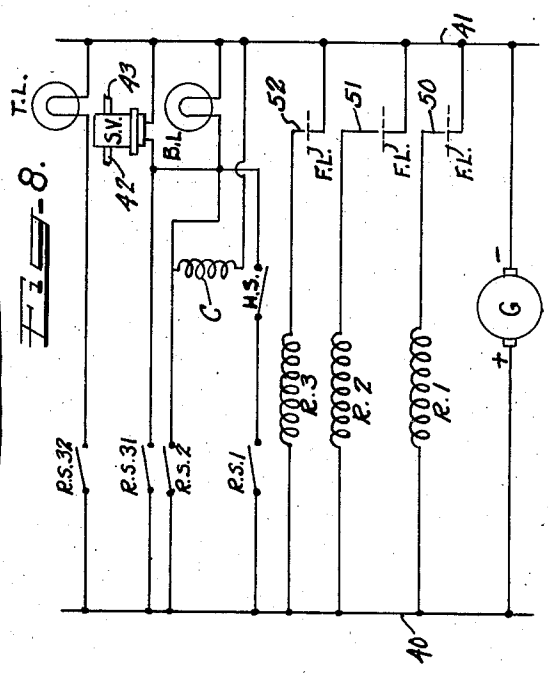

Fig. 8.

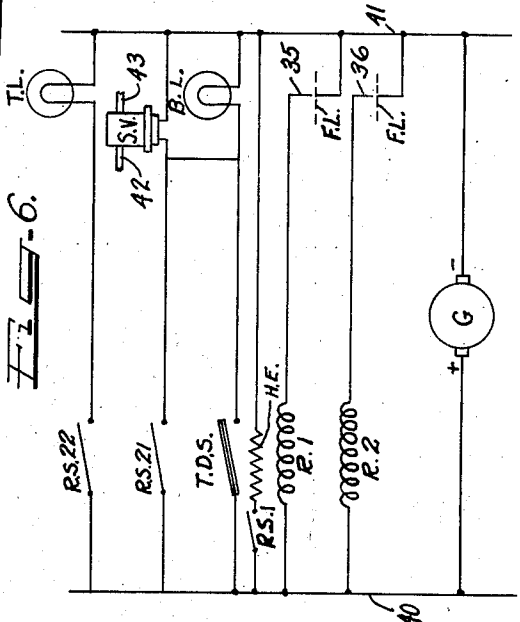

Fig. 6.

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Patented Feb. 1, 1944

2,340,468

UNITED STATES PATENT OFFICE

2,340,468

BOILER WATER CONDITIONER AND BLOWOFF SYSTEM

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Application December 4, 1941, Serial No. 421,556

12 Claims. (Cl. 122—389)

This invention relates to the removal of impurities from boiler water in operating steam boilers and to the maintenance of a clear steam channel under the stem outlet of the boiler.

More specifically, this invention relates to improvements in collecting troughs or receptacles for collecting light water and foam from the main boiler courses of operating steam boilers along a path extending from the hottest portion of the boiler to the steam outlet.

This application is a continuation in part of our copending application Serial No. 254,176, filed February 2, 1939, now Patent No. 2,282,775, issued May 12, 1942.

While the invention will hereinafter be described in connection with locomotive steam boilers, it should be understood that the invention is not limited to such use but is useful in steam boilers in general for controlling foaming of the boilers so that water or other impurities are not discharged with the steam.

Locomotive boilers include a water space, a steam space, a steam outlet communicating with the steam space, and a fire box in longitudinally spaced relation from the steam outlet. The hottest portion of the water space is adjacent the fire box and the boiler water thus flows forwardly from the fire box end of the water space. In accordance with this invention an elongated open topped trough is mounted in the boiler to extend from a point adjacent the fire box end thereof to a point forwardly of the steam dome with an intermediate portion passing directly under the steam dome. This trough is open along its entire length to the steam space but has side and end walls projecting above the normal water level so that good boiler water is received into the trough.

In locomotive boilers the low level of the water glass or gauge in the engineer's cab must be a minimum of three and one-half inches above the highest point of the crown sheet for the fire box. The water glass is usually about eight inches long so that with a full glass of water, the water level in the boiler will be about eleven and one-half inches above the crown sheet. In accordance with this invention the top of the collecting trough is positioned about two to eight inches above the top of the water glass or about thirteen to twenty inches above the crown sheet.

On the average the steam space above the water in the boiler with the water glass indicating one-half full is fifteen to twenty inches high. A full glass of water will reduce this space about four inches leaving eleven to sixteen inches of open space through which the steam must pass to the steam outlet. This steam space of normal height is well sufficient to permit the large volume of steam generated in the boiler to reach the steam dome or outlet pipe at relatively low speeds. However, when foaming develops in the boiler water the steam expanded or foaming water frequently fills the steam space to a point where the steam has little or no clear passage to the steam outlet.

Thus the steam path is closed up and the steam necessary for driving the locomotive must pass through a small space in sufficient volume to maintain operation. As a result, the steam approaches hurricane speeds and sweeps the water and foam into the outlet pipe.

The expansion or foaming of the water in the boiler resulting in a decrease in height of the steam space depends on several factors such as the rate of steam generation, the foaming characteristics of the feed water used in the boiler, and the like. When the rate of steam generation is high, the greatest swelling or foaming will occur. Frequently when the boiler is working under heavy load the entire steam space will be flooded with steam expanded water or foam and only very low quality steam can be delivered to the outlet pipe.

The present invention, however, maintains a clear steam channel extending from a short distance in front of the steam dome rearwardly underneath the steam dome to a point near the fire box. Even though the rest of the steam space is filled with foam or steam expanded water, the open topped trough of this invention will maintain the clear steam channel from the point of major steam generation to the discharge outlet because steam or light water spilling into the open topped trough will be collapsed and the collapsed water will be removed from the boiler automatically through electrode controls positioned at various levels in the boiler.

The elongated trough of this invention has a prow-like nose at the end thereof adjacent the fire box so as not to interfere with the forward flow of boiler water along the main course of the boiler. The main dry pipe of the locomotive extends through the other end of the trough and thence upwardly into the steam dome. The side walls of the trough can have doors provided therein so that access can be readily had to the interior of the steam boiler by removal of the steam dome.

In one embodiment of the blow-off system according to this invention a rear electrode is lo-

cated in the boiler to terminate about two inches above the top of the foam collapsing trough preferably at a point above the fire box or crown sheet. Whenever foaming water or solid water overflows into the trough and rises high enough to contact this rear electrode for twenty to thirty seconds, a time-delay switch is actuated to close a circuit which causes a light to show in the engineer's cab and at the same time causes a solenoid air valve to operate for opening a blow-off valve to remove water from the trough. As soon as the foam or water drops away from contact with this rear electrode the circuit is broken and, after a short delay period, the light goes out, the solenoid air valve closes, and the blow-off valve closes.

In this same modification a front electrode is located inside of the trough and ends preferably at a slightly higher level than the rear electrode. When foamy water contacts this electrode a pair of lights will show in the engineer's cab and the solenoid air valve and blow-off valve will open instantaneously to remove water from the trough and thereby clear the channel for free flow of steam to the outlet pipe.

In another embodiment of the invention double protection against water carry-over into the outlet pipe is provided. In this embodiment three electrodes are used above the collecting trough. A long electrode extends from the top of the boiler to a point near the bottom of the collecting trough. A medium electrode ends near the top of the trough, and a short electrode ends above the medium electrode. When foamy or solid water accumulates in the trough to contact the end of the medium electrode an electrical relay is closed lighting a signal light in the engineer's cab and opening a solenoid air valve to open a blow-off valve. This relay is kept closed until the blow-off valve removes water from the trough to a level below the end of the long electrode. When the electrical circuit is broken by the water dropping away from the long electrode, the signal light is extinguished and the blow-off valve is closed. The short electrode, when contacted by foamy or solid water, will actuate an electric circuit operating two signal lights in the engineer's cab and immediately cause the blow-off valve to open. This short electrode can be positioned above the trough or above the crown sheet.

The blowing off of the boiler is thus automatically accomplished through electrodes positioned at different levels in the boiler and the collapsed foam or light water in the elongated trough is removed. It has been found that the water collected in this trough contains a high concentration of foam producing impurities so that the discharge of water from the trough greatly aids the maintenance of reduced solids concentration in boiler water. In other words, the most contaminated water is removed from the boiler without sacrificing the less contaminated or good boiler water.

It is, then, an object of this invention to provide a long open-topped trough extending from a short distance in front of a locomotive steam dome rearwardly under the steam dome to a point near the fire box.

A further object of this invention is to maintain a clear steam channel along an open topped trough from a point of major steam generation in a boiler to the steam outlet of the boiler.

A still further object of this invention is to prevent water carry-over in locomotive boilers by collection of contaminated water in the boiler at levels of about thirteen to twenty inches above the crown sheet of the boiler.

A further object of the invention is to collect steam expanded or foamy water in an operating steam boiler along a path extending from the crown sheet of the boiler under the steam dome at a level above the normal water level in the boiler but below the level of the steam outlet.

A still further object of the invention is to automatically discharge contaminated water from a nonsteam generating channel in the upper portion of a boiler whenever foam or steam expanded water reaches a dangerous level and to continue the discharge of the collected water for maintaining a depressed clear steam channel in the boiler.

A specific object of the invention is to provide a foam collapsing trough for steam boilers with a prow-like end facing the normal flow of water in the boiler to prevent splashing and interference with the flow.

A still further object of the invention is to provide automatic electrode discharge control for collapsed foam and light water collected in the upper portion of the boiler to insure delivery of dry steam from the boiler.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed descriptions of the annexed sheets of drawings which, by way of preferred examples, illustrate two embodiments of the invention.

On the drawings:

Figure 1 is a fragmentary, somewhat diagrammatical side elevational view, with parts broken away and shown in vertical cross section, of a locomotive boiler equipped with the apparatus of this invention.

Figure 2 is a fragmentary top plan view of the boiler shown in Figure 1 with parts of the boiler shell broken away along the line II—II of Figure 1 to illustrate the foam-collapsing trough.

Figure 3 is an enlarged fragmentary vertical cross-sectional view with parts in elevation, of the foam-collapsing trough and electrode assembly of Figure 1.

Figure 4 is an enlarged vertical cross-sectional view, with parts in elevation, and with other parts omitted, taken along the line IV—IV of Figure 1.

Figure 5 is an enlarged vertical cross-sectional view, taken along the line V—V of Figure 1.

Figure 6 is a wiring diagram of the electrode system used in the embodiment of the invention shown in Figures 1 to 5.

Figure 7 is an enlarged vertical cross-sectional view, with parts in elevation, similar to Figure 3 but illustrating a modified electrode arrangement in accordance with this invention.

Figure 8 is a wiring diagram of the electrode system used in the embodiment of the invention shown in Figure 7.

As shown on the drawings:

In Figures 1 to 5 inclusive the reference numeral 10 designates generally a locomotive having the usual boiler shell 11 defining a boiler course 12. A fire box 13 is provided in the rear end of the boiler and fire tubes such as 14 project forwardly from the fire box 13 through the boiler course. The usual engineer's cab 15 (Figure 1) is mounted around the rear end of the boiler.

An opening 16 is provided in the top of a boiler shell 11 and the opening is covered with the usual steam dome 17. A steam throttle pipe 18 or main

outlet pipe to the operating cylinders of the locomotive extends upwardly at its inlet end into the steam dome 17. Turret pipes 19 or outlet steam pipes to the locomotive and train appurtenances extend forwardly from the rear end of the locomotive into the steam dome 17. Thus, the inlet openings to all steam outlet pipes of the locomotive boiler are in the steam dome 17 at levels above the top of the boiler shell.

The locomotive boiler thus has a steam outlet S. O. in the dome 17 thereof, a steam space S. S. along the top of the boiler, and a water space W. S. beneath the steam space. The water level W. L. in the boiler is maintained above the top wall or crown sheet of the fire box 13 as shown in Figures 1 and 3.

In accordance with this invention an open topped elongated box or trough 20 is suspended in the upper portion of the boiler on straps 21 secured to the boiler shell 11. The box 20 extends forwardly from the hottest portion of the boiler adjacent the fire box 13, under the steam outlet opening 16 of the boiler shell to a point forwardly of the steam outlet.

The box 20 has a bottom, side walls and end walls which cooperate to provide an elongated channel or nonsteam generating course in the steam space of the boiler. The side and end walls project into the steam space S. S. but terminate in spaced relation below the top of the boiler shell so as to place the entire interior of the box along its length in communication with the steam space. The top of the box is preferably about thirteen to fifteen inches above the crown sheet of the fire box, while the bottom of the box is submerged in the boiler water.

The end of the box 20 adjacent the fire box 13 has a prow-like nose 20*a* which, as best shown in Figure 2, is pointed at the longitudinal center line of the box and, as best shown in Figure 3, slopes backward from the upper edge of the box. This nose presents diverging end walls to the forward longitudinal flow of water in the boiler so as to interfere as little as possible with this forward flow and to prevent splashing of the boiler water as it hits the box.

The rear end wall 20*b* of the box, as best shown in Figure 4, has an opening 22 therethrough for receiving the throttle pipe 18. A collar or strap such as 23 (Figure 3) secures the box to the throttle pipe and seals the end wall against leakage around the throttle pipe.

The side walls 20*c* of the box or trough have cutaway portions under the steam outlet 16 so as to permit access to the interior of the boiler from the steam dome. These openings are normally closed by doors 24 which are hingedly connected as at 25 to the box so that they can be moved from vertical closed position to horizontal open position. The doors are held in closed positions by hasps or locking fingers 26 pivoted to the upper side edges thereof and having wall-engaging hook-like ends 26*a* adapted to engage the inner and outer faces of the adjacent wall portions 20*c*.

A blow-off valve 27 is mounted on the boiler shell and is connected through a pipe line 28 with an outlet 29 in a side wall 20*c* of the box 20 at the bottom thereof. The blow-off valve 27 discharges through a pipe line 30 into a steam and water separator 31 mounted on top of the boiler shell 11 as shown in Figure 1 in front of the engineer's cab 15. Steam released from the discharge water in pipe 30, is liberated by the separator 31 as at 32 into the atmosphere. The water and other liquid material is drained from the separator 31 to the road bed through a discharge line 33.

The box or trough 20 has a small vent hole or discharge opening 34 (Figure 4) in the other side wall 20*c* thereof to drain water from the bottom of the box back to the main boiler course. This drain opening only accommodates a small return flow of water collected in the trough back to the main boiler course to prevent opening of the blow-off valve 27 when boiler water merely spills into the top of the trough due to movement of the locomotive boiler as it rocks over an uneven track. It is not desired to discharge the boiler water which spills into the trough out of the boiler, and this small return opening 34 will accommodate drainage of good boiler water back into the main boiler course.

The actuation of the blow-off valve 27 is controlled by electrodes 35 and 36 mounted in the top of the boiler shell and projecting into the steam space S. S. of the boiler. The rear electrode 35 is mounted above the crown sheet of the fire box 13 and terminates at a level above the top of the collecting box 20. The front electrode 36 is mounted above the rear end of the box and projects into the steam space S. S. to the same level or a slightly higher level than the electrode 35. The electrode 35 is thus positioned at a very hot point in the boiler where maximum steam generation occurs. Whenever steam expanded water or foam contacts the electrode 35 for a continuous period of about twenty to thirty seconds, a circuit is completed to operate a time-delay switch which releases air to the blow-off valve 27 for opening the valve. Foam and light water collected in the trough will then be discharged out of the opening 29 in the box, through the pipe line 28 and out of the boiler through the open blow-off valve 27. The discharge will continue as long as the electrode 35 is in contact with water in the boiler. When the foam or water level drops away from the electrode 35 the valve 27 will remain open for a fixed period to substantially empty the trough 20.

When the electrode 36 contacts foamy or solid water the blow-off valve 27 is immediately opened. Thus the rear electrode 35 effects opening of the valve after the foam or light water has contacted it for a predetermined period while the front electrode immediately opens the valve because it receives the foam and light water closer to the steam outlet and at a point where the foam and light water is more apt to be entrained with the steam. The front electrode 36 is more of an emergency actuator for the system since it will not open until the box is completely filled and overflowing with the foamy material, whereas the rear electrode should have previously opened the discharge.

The time-delay mechanism controlled by the electrode 35 will be hereinafter described in connection with Figure 6.

As shown in Figure 2 the box 20 is open along the entire top thereof to the steam space and foam or light water developed on top of the main boiler water can spill into the trough at any point along the length thereof. Since the trough extends under the steam outlet it will protect the inlets of the pipes 18 and 19 and will prevent foam from rising into the steam dome to a level so as to enter the pipes. At the same time the trough maintains a clear steam channel from the hotter portion of the boiler adjacent to the fire box forwardly to the steam outlet point.

The electrodes control the discharge of the im-

purities collected in the elongated trough in the manner illustrated in the electrical diagram of Figure 6. As shown in Figure 6, a generator G or other source of current has the positive side thereof connected to a main line 40 and has the negative side thereof connected to a main line 41. A steam turbo-generator can conveniently be used as a source of electric current since the same can be driven by steam from the boiler. Whenever the foam level F. L. in the boiler contacts the rear electrode 35 current will flow between the wires 40 and 41 through a relay R_1 as shown. The relay R_1 closes a relay switch R. $S._1$ to flow current through a heating element H. E. for closing a time delay switch T. D. S. by heating a bi-metallic switch element therein. When the time-delay switch is closed current will flow through a bottom light B. L. in the engineer's cab to light the same and will also flow through the solenoid valve S. V. to open the valve. Thus the bottom light will be lit and the solenoid valve will be opened at a predetermined period after the foam level contacts the electrode 35. With the solenoid valve open, air under pressure from any suitable source on the locomotive can flow from pipe line 42 through the valve and into pipe line 43 for opening the air-controlled blow-off valve 27.

When the foam level F. L. subsides away from the electrode 35 the circuit through the relay R_1 will be broken and the relay switch R. $S._1$ will open. The heating element H. E. will thus start to cool and the time-delay switch T. D. S. will open as soon as the bi-metallic element thereof has been cooled sufficiently to cause the switch to open. Thus the solenoid valve S. V. will continue to be energized for a predetermined period even after the foam level has subsided from the electrode 35. This delayed action in closing the solenoid valve will permit the trough 20 to be substantially emptied.

When the foam level contacts the electrode 36 current will flow through a relay R_2 which will close normally open relay switches R. $S._{21}$ and R. $S._{22}$. Relay switch R. $S._{21}$ will energize the solenoid valve to permit air flow therethrough and effect an opening of the blow-off valve 27. Relay switch R. $S._{21}$ will also close a circuit to the bottom light B. L. to light the same. Relay switch R. $S._{22}$ will energize the top light T. L. in the engineer's cab. Thus, as soon as the electrode 36 contacts the foamy water, both lights will light and the blow-off will open. As soon as the foam level subsides from the electrode 36 both lights will shut off and the solenoid valve will close unless the electrode 35 is holding the time-delay switch T. D. S. in closed position. If the electrode 35 is holding the switch T. D. S. closed the bottom light only will remain on. The blow-off will then continue until the foam level subsides below the electrode 35 and the switch T. D. S. opens. The engineer thus has a visual knowledge of the blow-off but need not act because the blow-off is entirely automatic. However, if the top light T. L. stays on for prolonged periods, the engineer may actuate the manually controlled blow-off valve provided on the locomotive for more rapid clearing of the steam space.

In the embodiment shown in Figure 7 of the drawings parts substantially identical with parts described in Figures 1 to 5 inclusive have been marked with the same reference numerals. In Figure 7, however, a different electrode system is used. As therein shown, a long electrode 50 projects from the top of the boiler shell into the trough 20 near the rear end thereof to a level slightly above the bottom of the trough. A middle electrode 51 extends into the steam space of the boiler but terminates slightly below the top of the trough 20.

A short electrode 52 depends into the boiler and terminates at a level above the middle electrode 51 and above the trough.

As shown in Figure 8, the generator G energizes the main lines 40 and 41 as described above in connection with Figure 6. When the foam level F. L. in the trough 20 contacts the electrode 50, current will flow through relay R_1. The relay R_1 will effect a closing of the relay switch R. $S._1$ but current cannot flow through this switch R. $S._1$ until a holding switch H. S. is closed. Therefore, no discharge will be effected. However, as the foam level F. L. rises into contact with the middle electrode 51, current will flow through a relay R_2 to close a relay switch R. $S._2$ thereby causing current to flow through the bottom light B. L. in the engineer's cab to light the same. At the same time, however, current will also flow through a contactor C or actuator for the holding switch H. S. to close the switch H. S. Current will thus flow through the solenoid valve S. V. to connect the air pipes 42 and 43 and thereupon effect an opening of the blow-off valve for discharging the impurities out of the trough. When the foam level subsides away from the electrode 51 the relay switch R. $S._2$ will open but current will continue to flow through the contactor C thereby maintaining the holding switch H. S. in closed position and keeping the light B. L. lit as well as keeping the solenoid switch open. This current will flow through the contactor C until foam subsides away from the electrode 50 whereupon the relay switch R. $S._1$ will open thereby breaking the holding circuit and effecting an opening of the holding switch H. S. The solenoid valve and the bottom light will then shut off.

When foam rises to a level above the middle electrode and contacts the top electrode 52 a relay R_3 is energized to close the normally open relay switches R. $S._{31}$ and R. $S._{32}$. Relay switch R. $S._{31}$, when closed, flows current through the solenoid valve to open the same. Relay switch R. $S._{32}$, when closed, effects a lighting of the top light T. L. in the engineer's cab. When the foam level subsides away from the electrode 52 the relay R_3 will be de-energized and the switches R. $S._{31}$ and R. $S._{32}$ will be opened to shut off the top light. However, the solenoid valve S. V. will not be closed because the same will be receiving current from relay R_2. Even though relay R_2 is then de-energized, the valve will remain open and the bottom light will remain lit until relay R_1 is de-energized.

In the three-electrode system of Figure 7, therefore, the impurities in the trough first contact the long electrode 50 and, upon rising into contact with the middle electrode 51 they effect the closing of a circuit to open the blow-off valve and to light the bottom light in the engineer's cab showing that the blow-off valve is open. If foam development is quite rapid, and rises to a still higher level so as to contact the top electrode 52, an additional light is lit in the engineer's cab to show that bad foaming conditions exist in the boiler. If the top light remains lit for an appreciable time, the engineer may open a manually controlled blow-off valve for effecting a more rapid subsiding of the foaming conditions.

The top electrode is also useful as a safety de-

vice in the event that the middle electrode does not initiate the blow-off.

Once the blow-off has been started by either or both the top and middle electrodes 51 and 52, the blow-off will continue until the foamy water subsides below the level of the long electrode 50. Upon dropping away from the electrode 50 the circuits will all be broken and the blow-off valve will close, but the level of impurities in the trough will be near the bottom of the trough so that a clear steam channel is provided from the hot point of the boiler to the steam outlets 18 and 19.

From the above descriptions of two embodiments of this invention it should be understood that an open topped collecting box or trough is mounted in a steam boiler to extend under the steam outlet and longitudinally of the main flow of boiler water in the boiler as indicated by the arrows in Figure 2 of the drawings. The trough maintains an elongated clear steam channel from the hottest portion of the boiler to the steam outlet. Foam, light water or other impurities which rise to levels in the boiler tending to choke off the steam space must spill into the trough at some point along its length. Upon spilling into the trough the foam is collapsed and the impurities are collected in the trough for discharge out of the boiler whenever foamy water tends to choke off the steam space.

It will, of course, be understood that various details of construction may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

We claim as our invention:

1. In a steam boiler including a water space, a steam space, a steam outlet communicating with the steam space, and a fire box in longitudinally spaced relation from the steam outlet, the improvements of an elongated open topped trough mounted in the boiler to extend beneath the steam outlet and in a longitudinal direction therefrom toward the fire box, said trough being in communication with the steam space along its entire length and having sides and end walls spaced from the boiler walls and projecting into the steam space above the normal water level in the boiler for providing an inlet to the trough at a level below the steam outlet and above the normal water level to intercept into the trough foam and light water direct from the boiler water before the foam and light water reach the steam outlet, said trough defining an open topped elongated localized nonsteam generating clear steam channel to the steam outlet, and means for discharging materials collected into the trough out of the trough and boiler to maintain the clear steam channel.

2. In a steam boiler including a water space, a steam space, and a steam outlet, the improvement of an elongated open topped trough suspended in the boiler in spaced relation from the boiler walls and having side and end walls projecting into the steam space above the normal water level but terminating below the steam outlet, said trough extending from a point adjacent the hottest portion of the boiler under the steam outlet to maintain a clear steam channel to the outlet communicating along its length with the steam space, and means for discharging materials collected in the trough out of the boiler.

3. A foam collapsing trough for steam boilers comprising an open topped elongated box having a prow-like nose at one end thereof, an opening through the opposite end thereof adapted to receive a steam pipe therethrough, a side wall of said box having a cut-away portion, and a door for closing said cut-away portion of the side wall.

4. In a locomotive boiler having a water space, a steam space, a steam outlet and a fire box in spaced longitudinal relation from the steam outlet, the improvement of an elongated open topped collapsing box mounted in the boiler to extend longitudinally from a point adjacent the fire box under the steam outlet to a point forward of the steam outlet, said box having side and end walls projecting into the steam space but terminating at a level about thirteen to twenty inches above the top of the fire box, and said side and end walls being spaced from the walls of the boiler to provide communication between the box and steam space along the entire length of the box.

5. In a locomotive boiler having a water space, a steam space, a steam outlet above the steam space and a fire box in the water space in spaced longitudinal relation from the steam outlet, the improvements of an elongated open topped box suspended in the upper portion of the boiler in spaced relation from the boiler walls along the entire length of the box, said box extending under the steam outlet to a point adjacent the fire box, said open topped box having side and end walls projecting into the steam space but terminating beneath the steam outlet, electrodes projecting into the steam space of the boiler adapted to contact foam and light water when the same rises to a level above the top of the box, and means controlled by said electrodes for discharging impurities out of the box whenever the foam level reaches the levels of the electrodes.

6. In a locomotive boiler having a water space, a steam space, a steam dome above the steam space and a main throttle pipe extending through the steam space and having an inlet end projecting upwardly into the steam dome, the improvement of an elongated open topped foam collapsing trough extending under the steam dome and receiving the throttle pipe into one end thereof, said box being spaced from the boiler walls along its entire length, a drain outlet for said foam collapsing trough, a blow-off valve in said drain outlet, and electrode means suspended in the boiler to contact foam and light water when the same develops to levels above the top of the trough for opening the blow-off valve to remove impurities out of the trough.

7. An automatic foam-collapsing and blow-off system for boilers which comprises an elongated open topped foam-collapsing box mounted in the boiler to extend under the steam outlet in the direction of major water flow in the boiler, said box being spaced from the boiler walls along its entire length, a blow-off valve for said boiler, a drain line joining the lower portion of the open topped box with said blow-off valve, a drain outlet joining the bottom portion of the box with the interior of the boiler, and electrode means adapted to be contacted by water at levels above the top of the box for actuating the blow-off valve to discharge materials out of the box.

8. In an automatic blow-off system for steam boilers including a light water and foam-collapsing trough mounted in the upper portion of the boiler in spaced relation from the boiler walls throughout the entire length of the trough to receive impurities directly from the boiler water at a level above the normal water level but below the steam outlet of the boiler, the improvements

of a pair of electrodes projecting into the steam space of the boiler to contact foam and light water in the boiler at levels above the top of the collapsing trough, a relay circuit energized by one of said electrodes, a time-delay circuit actuated by said relay circuit, a solenoid valve actuated by the time-delay circuit, a blow-off valve communicating with the lower portion of the collecting trough actuated by said solenoid valve for removing impurities from the trough, a second relay circuit actuated by the other of said electrodes connected to the solenoid valve for immediately opening the same to open the blow-off valve whereby the first mentioned electrode will effect discharge of impurities out of the trough only after the foam and light water remain in contact therewith for a predetermined time while the second electrode will effect immediate opening of the discharge valve upon contacting the foam and light water.

9. An automatic impurity-collecting and discharge system for steam boilers which comprises an open-topped collecting box mounted in the boiler to extend under the steam outlet and arranged to receive foam and light water direct from the boiler water along the entire length of the box at a level above the normal water level in the boiler but below the steam outlet, an electrode projecting into the collecting box to a level near the bottom thereof, a second electrode projecting into the steam space of the boiler near the top of the collecting box, a solenoid air valve, an air operated blow-off valve controlled by the solenoid valve, a drain outlet for the collecting box connected to the blow-off valve, an electrical circuit closed by foam and light water contact with both of said electrodes to actuate the solenoid valve for opening the blow-off valve, and holding means in said electrical circuit to maintain the solenoid valve in open position for continuing the blow-off until the foam and light water level subsides below the longer electrode projecting into the box.

10. The method of preventing water and impurity carry over into steam outlets of operating steam boilers which comprises forming a non-steam generating localized elongated course beneath the steam outlet of the boiler and extending toward the hottest portion of the boiler, collecting impurities directly from the boiler along the entire length of said course at a level below the steam outlet but above the normal water level, and discharging the collected impurities to main tain a non-steam generating clear steam channel along the length of the course to the steam outlet.

11. The method of operating steam boilers to produce high quality steam which comprises collecting impurities from the boiler water along all of an elongated path extending from the hottest portion of the boiler to and under the steam outlet at a level beneath the steam outlet but above the normal water level, and discharging the collected impurities out of the boiler whenever the foam and light water level in the boiler rises above a predetermined level.

12. The method of operating locomotive boilers to prevent impurities from entering the throttle pipe of the boiler which comprises forming an open topped elongated nonsteam generating course in the upper portion of the boiler from the inlet end of the throttle pipe to a point adjacent the fire box of the boiler, collecting foam and light water directly from the boiler water along the entire length of the course at a level about thirteen to twenty inches above the top of the fire box, and blowing the collected impurities out of the localized course whenever foam and light water are developed to a predetermined level in the boiler.

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