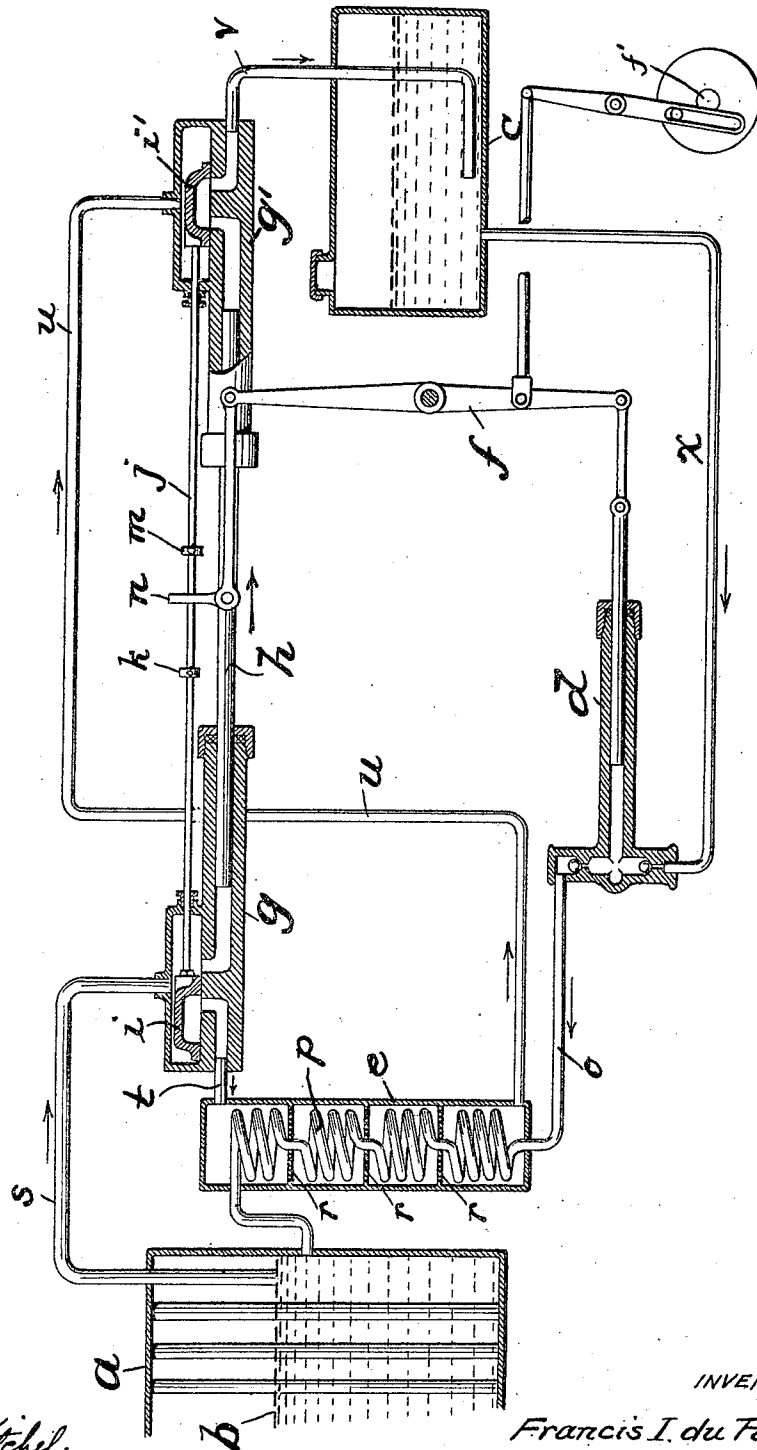


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 WATER LEVEL REGULATOR FOR STEAM BOILERS.  
 APPLICATION FILED MAY 17, 1919.

1,401,894.

Patented Dec. 27, 1921.



WITNESS:

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# UNITED STATES PATENT OFFICE.

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## WATER-LEVEL REGULATOR FOR STEAM-BOILERS.

1,401,894.

Specification of Letters Patent. Patented Dec. 27, 1921.

Application filed May 17, 1919. Serial No. 297,912.

*To all whom it may concern:*

Be it known that I, FRANCIS I. DU PONT, a citizen of the United States, residing at Wilmington, county of New Castle, and State of Delaware, have invented a new and useful Improvement in Water-Level Regulators for Steam-Boilers, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, which form a part of this specification.

My invention has for its object the automatic maintenance of a constant level of water in steam boilers. It is especially applicable to steam-driven automobiles, and in such application has its greatest utility and value for the reason that it is particularly desirable in these vehicles that the driver's attention should be confined to as few duties as possible.

The invention consists of means to pump water from a water reservoir or tank to the boiler; means to return water from the boiler to the tank at a rate exceeding, or at least not less than, the rate at which the water is pumped to the boiler; a heat interchanger arranged to transfer heat from the water flowing away from the boiler to the water flowing toward the boiler to prevent the waste of heat that would otherwise occur, and means, dependent upon the maintenance of a constant volume of water in the circulatory system or upon the maintenance of the same rate of flow to and from the interchanger, to prevent the conversion into steam of the water flowing from the boiler, so as to insure the exchange of the maximum amount of heat before the return of the water to the tank.

In an application filed by me March 29, 1918, Serial No. 225,464, I have set forth a similar invention, which, however, differs from my present invention in that the means to prevent the conversion into steam of water flowing from the boiler comprises a differential valve which yields to allow water to flow to the tank only when the pressure in the heat interchanger reaches a predetermined degree below boiler pressure. In other words, pressure is relied upon to insure the exchange of the maximum amount of heat before the return of the water to the tank. In the present invention I provide means whereby the flow of water

to the heat interchanger and the flow of the same water from the heat interchanger to the tank are maintained at the same rate. Specifically this is effected by intermittently transferring to the heat exchanger water that has been withdrawn from the boiler and coincidentally therewith providing, for the reception of the water thereby displaced from the interchanger, a space equal to the volume of water displaced; and alternately therewith, closing the inflow of water to, and outflow of water from, the interchanger and coincidentally therewith drawing water from the boiler and discharging into the tank the water just displaced from the interchanger. In other words, a constant volume of water is maintained in the interchanger and in the inflow and outflow connections therefrom both while those connections are blocked and during the delivery of water to, and its discharge from, the interchanger.

*a* represents the steam boiler; *b* the desired water level therein; *c* the water tank from which the boiler is kept supplied; and *d* the feed pump, which takes water from the bottom of the water tank through pipe *x* and delivers it through pipe *o* and the heat interchanger *e* into the boiler.

The plunger of the pump *d* is actuated by a connecting rod from one arm of a walking beam *f*, which in turn is actuated by any means, but preferably by some mechanism geared to the steam engine which is being supplied by the boiler *b*, such as a connecting rod connected to the shaft *f'* of the engine. The other arm of the walking beam *f* is connected to the plunger of what may be called a duplex measuring engine. Each engine comprises a cylinder and a plunger, the two engines *g* and *g'* having preferably a common plunger. The cylinders of the two engines have the same capacity. *h* is the common plunger. Each cylinder has at least as great a capacity as, and preferably a slightly greater capacity than, the cylinder of feed pump *d*. The cylinder of engine *g* has ports and a slide valve *i*. The cylinder of engine *g'* has ports and a slide valve *i'*. The two slide valves have a common stem *j* carrying two lugs *k* and *m* which are in the path of travel of a tappet *n* on the plunger *h*.

The heat interchanger can be of any of

the well known forms, but that shown consists in a coil  $p$  for the feed water extending through a chamber in which is a series of diaphragms  $n$ , each perforated with a small hole, thus dividing the interchanger into a series of superimposed chambers, the upper one of which contains the hottest water and transfers heat in the greatest degree to the coil through which the feed water passes. The other chambers grade downward in temperature as the incoming feed water takes heat away from them.

A pipe  $s$  extends from a point within the boiler at the level at which it is desired to maintain the water in the boiler to the measuring engine  $g$ . A pipe  $t$  connects the measuring engine  $g$  and the upper chamber of the heat interchanger. A pipe  $u$  connects the lower chamber of the heat interchanger with the measuring engine  $g'$ . A pipe  $v$  connects the measuring engine  $g'$  with the tank  $c$ .

Assume that the plunger  $h$  is in the position shown in the figure and moving to the right. In this position engine  $g$  is receiving water from the boiler, there is no water flowing from engine  $g$  to the interchanger or from the interchanger to engine  $g'$ , and the engine  $g'$  is forcing water into the tank  $c$ . Just before the end of this stroke of the plunger, tappet  $n$  moves the common valve stem to the right, which shifts the valve  $i$  to close communication between the pipe  $s$  and the cylinder of the measuring engine  $g$  and open communication between the cylinder of the measuring engine  $g$  and the pipe  $t$  leading to the interchanger, and shifts the valve  $i'$  to open communication between the pipe  $u$ , leading from the interchanger, and the cylinder of engine  $g'$ , and close communication between the cylinder of engine  $g'$  and the tank  $c$ . In the stroke of the plunger  $h$  to the left, water is discharged from the cylinder of measuring engine  $g$  to the interchanger, while it is discharged from the interchanger, at exactly the same speed, into the cylinder of the measuring engine  $g'$ . This operation continues until tappet  $n$  moves the common valve stem to the left, which shifts the valve  $i$  and  $i'$  into the position shown in the figure, thereby opening communication between the boiler and the cylinder of the measuring engine  $g$ , closing communication between the cylinder of the measuring engine  $g$  and the interchanger, closing communication between the interchanger and the cylinder of engine  $g'$  and opening communication between the cylinder of engine  $g'$  and the tank  $c$ . In the movement of the plunger  $h$  to the right, water is flowing from the boiler to the cylinder of measuring engine  $g$ , while water is discharging from the cylinder of measuring engine  $g$  to the tank  $c$ .

As long as the water level in the boiler  $a$

is above the end of the pipe  $s$ , the cylinder of engine  $g$ , being of greater capacity than the cylinder of the feed pump  $d$ , will take more water out of the boiler than the feed pump can deliver into it. When, however, the level of the water in the boiler falls below the end of the pipe  $s$ , the latter will receive only steam, and the water level in the boiler will rise until equilibrium is established.

The heat interchanger  $e$  is not a substitute for the usual feed water heat operating by exhaust steam from the engine. Should an ordinary heater be used it must be introduced in the pipe  $o$  between the feed pump and the heat interchanger. The purpose of the interchanger is to neutralize what would otherwise be a waste of heat resulting from a continuous withdrawal of hot water from the boiler.

By means of this interchanger the heat units in the stream of withdrawn water are immediately transferred to the ingoing feed water and substantially no heat is lost.

The importance of this is at once recognized when the state of affairs in a steam automobile which is running down hill is considered. Here the feed pump (which is usually geared to the axle) is working and a stream of water is being pumped into the boiler, but the engine is not using any steam. With the present day steam automobiles, the feed pump must be by-passed either by a hand operated valve or by a device dependent on expansion of metals, which does not always work satisfactorily. If this is not done, the boiler becomes too full. My device not only renders it impossible for the boiler to become too full, but prevents the loss of heat units due to pumping into the boiler water which, by reason of the fact that the engine is not delivering any exhaust steam, has not been heated.

If the exit from the heat interchanger to the tank were full and unobstructed, the water, as soon as delivered through the pipe  $t$  into the chambers of the interchanger  $e$ , would, owing to its high temperature, flash into steam and rush out into the tank  $c$  at atmospheric pressure. This would leave the chambers of  $e$  full of steam at atmospheric pressure. Under these circumstances, very little of the heat due to the boiler pressure would be saved by the interchanger.

This, however, is obviated by the supplemental or auxiliary measuring engine  $g'$  which does not permit the water to flow out of the interchanger more rapidly than it flows into the interchanger. In other words, the system between the two measuring engines is slightly below boiler pressure, thereby preventing the conversion of water into steam and insuring the exchange of the maximum amount of heat before the exit of the water from the interchanger.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:

1. In an apparatus for regulating the water level in a steam boiler, means to deliver an excess supply of water to the boiler, a discharge from the boiler at the desired water level, a heat interchanger interposed in the delivery and discharge connections, and means for removing the discharged water from the interchanger at the rate delivered thereto.

2. In an apparatus for regulating the water level in a steam boiler, means to deliver an excess supply of water to the boiler, a discharge from the boiler at the desired water level, a heat interchanger interposed in the delivery and discharge connections, means in the discharge between the boiler and the heat interchanger for withdrawing the excess water from the boiler and delivering it to the interchanger, and means for removing the discharged water from the interchanger at the rate delivered thereto.

3. In an apparatus for regulating the water level in a steam boiler, a water inlet pipe, means for constantly delivering water at a predetermined rate to the boiler through said pipe, a discharge pipe for the excess water leading from the boiler at the desired water level, a heat interchanger connected to the inlet and discharge pipes, an excess water remover in the discharge pipe between the boiler and the heat interchanger, and a second water remover in the discharge pipe beyond the heat interchanger arranged to remove the water from said interchanger as fast as delivered thereto by the first water remover and means for actuating said removers.

4. In an apparatus for regulating the water level in a steam boiler, a water inlet pipe, means for constantly delivering water at a predetermined rate to the boiler through said pipe, a discharge pipe for the excess water leading from the boiler at the desired water level, a heat interchanger connected to the inlet and discharge pipes, a measuring engine connected to the discharge pipe between the boiler and the interchanger through which the excess water passes to the interchanger, a pump beyond the interchanger connected to the discharge pipe and arranged to force the water through the discharge pipe as fast as delivered to the interchanger.

5. A water feed system for boilers comprising a feed water inlet pipe, a feed pump for continuously forcing water at a predetermined rate through said inlet pipe, an outlet pipe connected to the boiler at the desired water level, the open end thereof being at the water level of the boiler, a heat interchanger, said heat interchanger having separate connections with the inlet and out-

let pipes, a measuring engine connected to the outlet between the boiler and the interchanger, the capacity of said measuring engine being at least as great as the capacity of the feed pump, a second pump connected to the outlet pipe beyond the interchanger and arranged to remove the water from the interchanger as fast as delivered thereto.

6. In an apparatus for regulating the water level in a boiler, a supply tank, a delivery pipe leading from the tank to the boiler, a pump connected to said pipe for delivering water at a predetermined rate to the boiler, an outlet pipe leading from the boiler to the tank, a heat interchanger having separate connections with the inlet and outlet pipes, a measuring engine connected to the outlet pipe between the boiler and the interchanger, and means connected to the outlet pipe beyond the interchanger arranged to transfer the water from the interchanger to the tank as fast as delivered to the interchanger.

7. A water supply system for steam boilers comprising a water supply line for the boiler, including a pump, a water discharge line leading from the boiler at the desired water level, a heat interchanger connected to the supply and discharge lines, a water remover between the heat interchanger and the boiler connected to the discharge line, said remover having a cylinder and a piston therein, a valve for controlling the admission of fluid from the boiler to the cylinder and from the cylinder to the interchanger, connections between the valve and the piston for actuating the valve in timed relation thereto, a second water remover in the discharge line beyond the heat interchanger, and actuating means for the removers and the pump.

8. A water supply system for steam boilers comprising a water supply line for the boiler, including a pump, a water discharge line leading from the boiler at the desired water level, a heat interchanger connected to the supply and discharge lines, a water remover between the heat interchanger and the boiler connected to the discharge line, said remover having a cylinder and a piston therein, a valve for controlling the admission of fluid from the boiler to the cylinder and from the cylinder to the interchanger, connections between the valve and the piston for actuating the valve in timed relation thereto, a second water remover in the discharge line beyond the heat interchanger having a cylinder and a piston therein, a valve for controlling the admission of fluid to the cylinder from the heat interchanger and from the cylinder to a discharge, connections between said last mentioned piston and valve for actuating the valve in timed relation to the piston, and actuating connections for the removers and the pump.

9. A water supply system for steam boilers comprising a water supply line for the boiler, including a pump and a water supply tank, a water discharge line leading from the boiler at the desired water level, a heat interchanger connected to the supply and discharge lines, a water remover between the heat interchanger and the boiler connected to the discharge line, said remover having a cylinder and a piston therein, a valve for controlling the admission of fluid from the boiler to the cylinder and from the cylinder to the interchanger, connections between the valve and the piston for actuating the valve in timed relation thereto, a second water remover in the discharge line beyond the heat interchanger having a cylinder and a piston therein, a valve for controlling the admission of fluid to the cylinder from the heat interchanger and from the cylinder to a discharge leading to the supply tank, connections between said last mentioned piston and valve for actuating the valve in timed relation to the piston, and actuating connections for the removers and the pump.

10. A water supply system for steam boilers comprising a water supply line for the

boiler, including a pump, a water discharge line leading from the boiler at the desired water level, a heat interchanger connected to the supply and discharge lines, a water remover between the heat interchanger and the boiler connected to the discharge line, said remover having a cylinder and a piston therein, a valve for controlling the admission of fluid from the boiler to the cylinder and from the cylinder to the interchanger, connections between the valve and the piston for actuating the valve in timed relation thereto, a second water remover in the discharge line beyond the heat interchanger having a cylinder and a piston therein, a valve for controlling the admission of fluid to the cylinder from the heat interchanger and from the cylinder to a discharge, connections between said last mentioned piston and valve for actuating the valve in timed relation to the piston, and interconnected actuating connections for the removers and the pump.

In testimony of which invention, I have hereunto set my hand, at Wilmington, Delaware, on this 9th day of May, 1919.

FRANCIS I. DU PONT.