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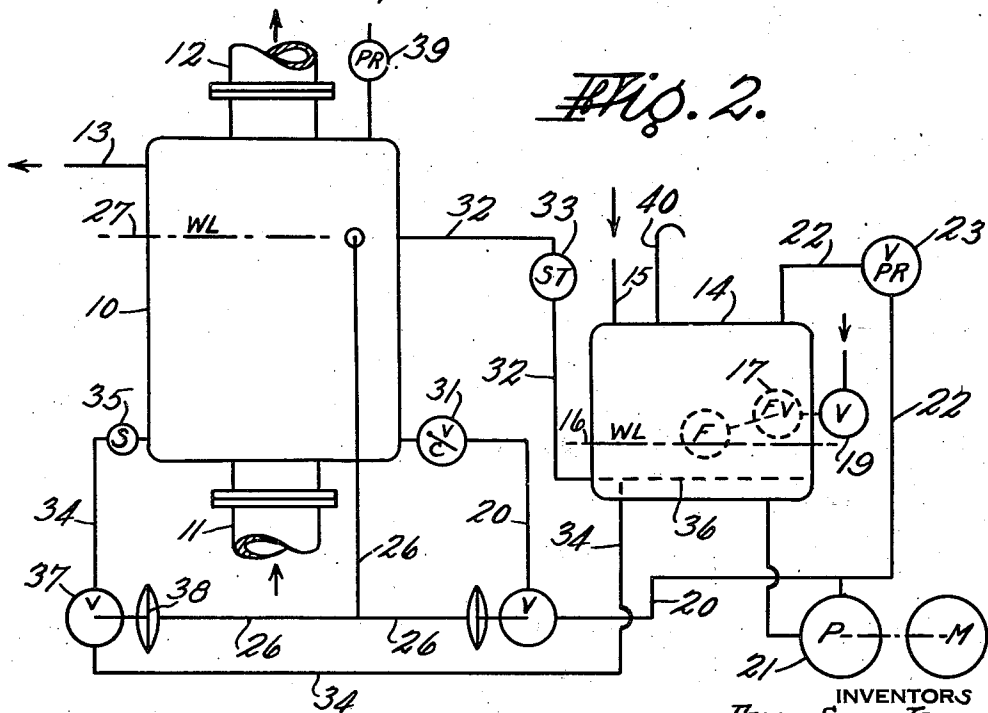
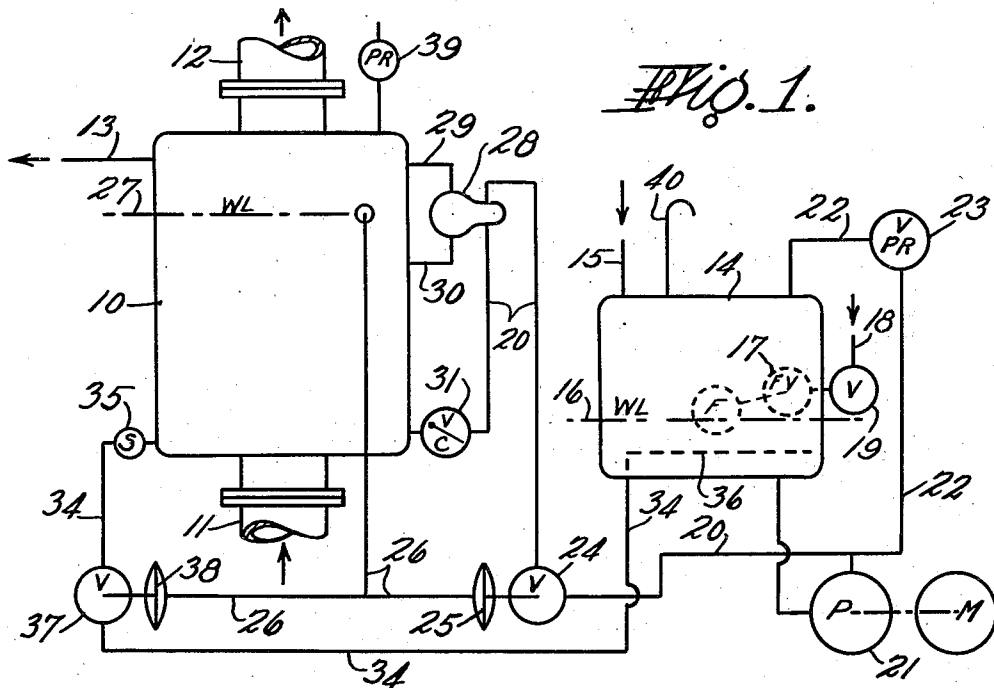
F. SACO, JR., ET AL

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AUTOMATIC CONTROL FOR WASTE HEAT BOILERS

Filed Aug. 15, 1942

2 Sheets-Sheet 1



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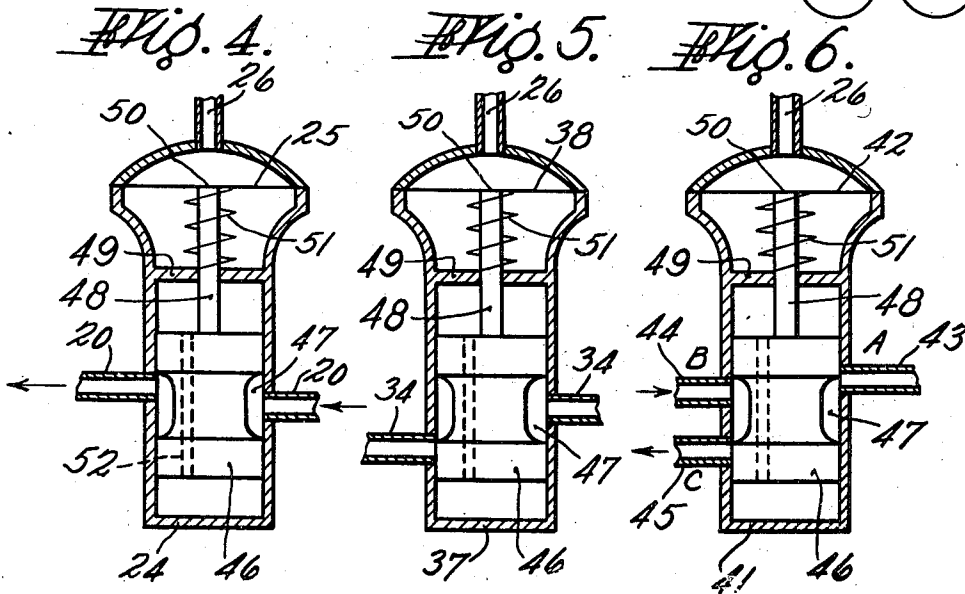
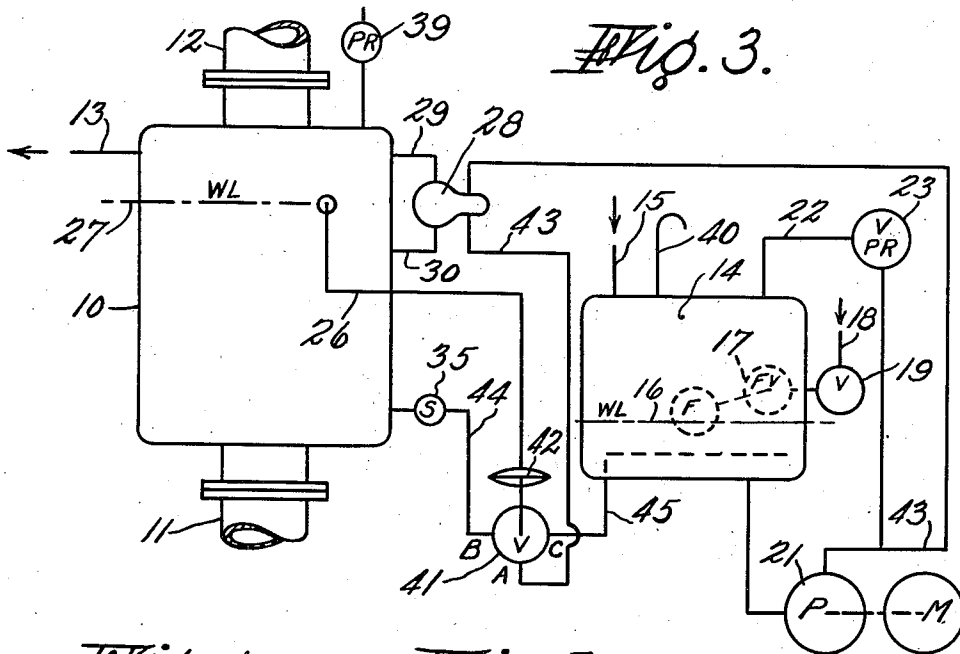
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AUTOMATIC CONTROL FOR WASTE HEAT BOILERS

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AUTOMATIC CONTROL FOR WASTE
HEAT BOILERS

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9 Claims. (Cl. 122—7)

This invention relates to apparatus for utilizing the waste heat from the exhaust gases of internal combustion engines, or other low temperature gas source, and in particular is concerned with an automatic control for a waste heat boiler system.

The principal object of the invention is to vary automatically the amount of heating surface in the boiler which is in contact with the water therein whereby the heat transferred from the gases to the water varies in accordance with the steam demand. Thus the steam generated may be made to vary from zero, when no water is in the boiler, to a maximum; depending upon the amount of heat available and the size and efficiency of the boiler. Due to the relatively low temperatures found in the exhaust gases of internal combustion engines, no damage to the boiler results from its running dry.

In the system described herein, this automatic control is preferably accomplished by the use of two steam pressure operated valves, one of which governs the flow of feed water to the boiler and the other of which governs the flow of water from the boiler to a condensate receiver.

This system differs from the automatic control system described by us in our United States patent application Serial No. 426,868, filed January 15, 1942, in that the prior system involved the use of a gravity feed drum external to the boiler whereby an increase in steam pressure resulting from a decrease in steam demand forced water from the boiler into the drum against gravity, thus reducing the contact area of the boiler and so the amount of steam generated. A reducing valve in the steam line between the boiler and external drum permitted the system to be adjusted to operate at a predetermined steam pressure, and permitted a pressure differential to exist between the boiler and the external drum whereby the flow of water into and out of the boiler took place.

In automatic control systems of this type wherein a change in operating conditions initiates a correcting procedure, a certain time lag is introduced resulting in a cyclic change commonly called "hunting." Thus, the steam pressure may slowly vary plus and minus from a predetermined value. This is ordinarily of no great importance, but it is desirable to reduce the amount of hunting to a minimum. In the system described herein, it is of prime importance to have a steam pressure operated valve in the water supply line to the boiler. Thus, when the steam demand is reduced, the pressure in the boiler rises and this

in turn shuts off the water supply. Hunting due to this valve alone is reduced by having this feed line valve of the gradual closing type. A simple, spring loaded, pressure relief valve may be used in the return line between the boiler and a condensate tank. We prefer, however, to use a steam pressure operated relief valve rather than the simple spring loaded valve, since the latter is also affected by the water head in the boiler and therefore would not close at a definite predetermined steam pressure. Furthermore, the steam pressure operated relief valve, in conjunction with the inlet valve, above described, may be so adjusted as to reduce hunting to a very satisfactory low value.

Thus far, we have referred to the control valves as being operated directly by steam pressure, but we point out that they may be operated indirectly by steam pressure through an intermediate system involving electrical, mechanical or hydraulic linkages. For simplicity in describing the invention, however, we shall refer to these valves as being directly operated by the steam pressure in the boiler.

The functions of the two valves above described may be exercised by a single, pressure operated, three-way valve, if the design considerations so indicate.

For a more complete understanding and description of the invention, we refer to the drawings in which,

Fig. 1 shows a schematic diagram of a system involving two separate steam pressure operated valves;

Figs. 2 and 3 are similar diagrams of modifications; and

Figs. 4, 5, and 6 are diagrammatic representations of conventionalized diaphragm-controlled valves.

Referring now to Fig. 1, the waste heat boiler 10 is shown as having a gas inlet connection 11 and a gas outlet connection 12. Steam generated in the boiler 10 passes to the load through the steam outlet 13 and the condensate from the load returns to a condensate tank 14 through the condensate return 15. The condensate tank is generally located at a lower level than the boiler, particularly on ships, but it may if desired be on substantially the same level as shown. There is always a certain amount of water in the tank 14, its minimum level 16 being controlled by a float-operated valve 17 inserted in the water make-up line 18 which also has a manually operated valve 19, in accordance with customary practice.

Water is pumped from the tank 14 to the boiler

10 through the feed line 20 by means of the boiler feed pump 21, which is ordinarily in continuous operation. A by-pass line 22 which includes a relief valve 23 permits this pump to circulate excess water directly back into the condensate tank 14. In the feed line 20 is inserted the steam pressure operated valve 24 actuated by the diaphragm 25 by steam pressure obtained through the small pressure line 26 which is connected to the boiler 10 at or near the high water level 27. This high water level is controlled by means of the float type feed water regulator 28 of usual construction, having equalizer legs 29, 30, respectively in accordance with standard practice. A check valve 31 in the feed line prevents water from entering the feed line from the boiler.

An alternate method of regulating the maximum water level in the boiler is to use an overflow pipe as shown at 32 in Fig. 2, this pipe containing a steam trap 33 and being connected between the boiler 10 at the desired height and the condensate tank 14. The steam trap prevents the passage of steam but allows excess water to be drawn off and so returned to the tank 14.

To continue with the description of the preferred embodiment of Fig. 1, a return line 34, having a strainer 35 inserted therein, leads from a point near the bottom of the boiler 10 to the submerged heater 36 in the condensate tank 14. Inserted in the return line 34 is the steam pressure operated relief valve 37 having a diaphragm 38 which is actuated by steam pressure in the afore-mentioned small pressure line 26. The valve 37 is so connected and arranged that it closes when the steam pressure on the diaphragm 38 is reduced, whereas the valve 24 in the feed line 20 is so connected that it opens when the steam pressure on the diaphragm 25 and, therefore in the boiler 10, is reduced. Since the water in the boiler may generate a certain amount of flash steam as its pressure is reduced to atmospheric, it is customary to pipe return water into the condensate tank through a submerged heater 36 which is in the form of a perforated tube. This steam then transfers its heat directly to the water 16 in the tank 14. Should the demand for steam be so suddenly reduced that the water level in the boiler could not be lowered sufficiently rapidly, excess steam pressure built up is relieved by the safety valve 39. The condensate tank 14 is fitted with a vent 40, to atmosphere.

In operation, the system functions as follows:—With a given amount of heat being supplied the boiler from, say, the exhaust of an internal combustion engine, and for a given steam demand at a predetermined pressure, there will exist in the boiler a certain definite mean water level. Should the steam demand be decreased, as by shutting off a number of radiators, for example, the steam pressure in the boiler will increase. This increased steam pressure immediately closes or starts to close the valve 24, thus reducing the amount of water supplied to the boiler. At the same time, the increased steam pressure opens the relief valve 37 and permits water to flow out of the boiler into the condensate tank 14. As soon as water flows out of the boiler, more heating surface is uncovered and therefore, since the amount of heat in the exhaust gases is constant, the boiler generates less steam. This goes on until the steam pressure is reduced to the normal operating value, when the original status of equilibrium is restored. The valve 37 is preferably adjusted to open a little ahead of the closing

ing of the valve 24, since by this means the water level is more quickly lowered to the proper value. The water drained off from the boiler flows into the condensate tank, which should have a capacity slightly in excess of the total water capacity of the boiler.

Assuming now an increase in steam demand, the converse action takes place. The increased demand reduces the pressure in the boiler. The valves 24 and 37 now conspire, it will be obvious, to raise the water level in the boiler to a point where sufficient contact area is provided to generate the necessary steam to satisfy the demands. When the demand for steam becomes greater than can be satisfied by the maximum amount of water in the boiler, no more additional steam will be generated—the capacity of the boiler will then have been reached. As before stated, the safety valve 39 will relieve any rapidly incurred excess steam pressure that cannot be taken care of by the reduction of water level in the boiler.

For the condition where the demand for steam remains unchanged, but the load on the internal combustion engine supplying exhaust gas to the boiler is changed, the system operates to maintain constant steam output. For instance, should the heat be supplied to the boiler at a reduced rate, as would be occasioned by running the engine at lighter load, the steam pressure will drop. This drop in steam pressure actuates the valves 24 and 37 in the same manner as previously described. The water level of the boiler is increased a proper amount whereby the necessary steam is generated. It will be seen that the water level in the boiler will be higher for less exhaust gas heat, so that the total amount of heat converted into steam, within the limits of capacity of the device, will remain a constant, for constant steam demand.

The functions of the two pressure operated valves 24 and 37 may be performed by a single steam pressure operated three-way valve, as shown in Fig. 3. In this case, the main piping arrangements are similar to those shown in connection with Fig. 1. Instead of two valves 24, 37 of Fig. 1, we have provided a three-way valve 41 operated by steam pressure upon the diaphragm 42. This valve 41 is so constructed that at one extreme position there exists a passageway between A and B, which we will refer to simply as AB. At the other extreme position, the passageway through the valve is BC. With AB open and BC closed, water can enter the boiler from the pump 21 through feed line 43, passages A and B, and line 44; but none can leave the boiler. With BC open and AB closed, water can leave the boiler through line 44 and flow into the condensate tank 14 through passages BC and line 45, but none can enter through the feed line 43. For any intermediate set of conditions, the valve will adjust itself to give a balanced flow of water into and out of the boiler. In operation, a reduced steam demand increases the boiler pressure which, in turn, closes the feed line and opens the return line. The action is similar to that which takes place using the two valves of Fig. 1.

In Figs. 4, 5, and 6 are illustrated in a conventional manner diaphragm control construction suitable for the valves 24, 37, and 41 respectively. It will be understood that standard commercial valves may be used, and these figures are intended to clarify the action of the valves rather than to disclose their mechanical construction. Each

valve has a piston 46 provided with a central circumferential groove or cannellure 47. A piston rod 48 passes through a partition 49 and is coupled to the diaphragm at 50. A spring 51, which may be adjustable as in most commercial embodiments, opposes the fluid pressure placed on the diaphragm through pipe 26. A balancing aperture 52 preferably extends through the piston to relieve it of endwise pressure. The valves are identical except for the arrangement of the ports which has been described above. It will be obvious that the relation in which the feed and exhaust lines close and open, respectively, can be varied either by changing the initial positions of the pistons, the tension of the springs, the position of the ports, or all three.

The above described control systems are, of course, not limited to the exact lay-outs described, but may be used in conjunction with separate oil-fired boilers, which are generally used in marine installations to generate steam while the vessel is in port, or in connection with other waste heat boilers.

What we claim is:

1. A method for controlling the amount of steam generated in a steam boiler heated by gases having a temperature below that which would damage the boiler when dry, which comprises supplying the boiler with water under pressure during periods of normal consumption of steam, connecting the boiler below its minimum water level to a sump through a vent closed during periods of normal consumption of steam, throttling the supply with an increase in steam pressure within the boiler, and throttling the vent with a decrease in said steam pressure.

2. A method for controlling the amount of steam generated in a steam boiler heated by gases having a temperature below that which would damage the boiler when dry, which comprises controllably supplying the boiler with water under pressure, controllably venting the boiler from a point below its minimum water level to a sump, opening said vent upon increase of steam pressure within the boiler beyond normal, and subsequently closing said supply upon a further increase in said pressure.

3. A method for controlling the amount of steam generated in a steam boiler heated by gases having a temperature below that which would damage the boiler when dry, which comprises controllably supplying the boiler with water under pressure, controllably venting the boiler from a point below its minimum water level to a sump, and substantially simultaneously opening said vent and closing said supply upon increase of steam pressure within the boiler beyond normal.

4. A method for controlling the amount of steam generated in a steam boiler heated by gases having a temperature below that which would damage the boiler when dry, which comprises controllably supplying the boiler with water under pressure, controllably venting the boiler below its minimum water level to a sump, opening said vent and closing said supply upon increase of steam pressure within the boiler beyond normal, and closing the vent and opening the supply upon decrease of said pressure beyond normal.

5. A waste heat boiler of the type supplied with heat at a temperature below that which would damage the boiler when dry, comprising a feed line to the boiler for water under pressure,

a water return line from the boiler, valves in said lines, and means responsive to increase or decrease in steam pressure with respect to normal operating pressure in the boiler for closing the feed line valve and opening the return line valve or opening the feed line valve and closing the return line valve respectively.

6. A control system for a waste heat boiler of the type supplied with heat at a temperature below that which would damage the boiler when dry, a tank of a size sufficient to receive all the water from the boiler, a return line from the boiler to the tank, a feed line connecting the tank with the boiler, a constant output feed pump in the line, a valve in said line, a by-pass operative to return to the tank all water delivered by the pump in excess of the flow permitted by the valve, and means controlling the degree of opening of said valve in inverse proportion to the pressure of steam in the boiler.

7. A control system for a waste heat boiler of the type supplied with heat at a temperature below that which would damage the boiler when dry, a tank of a size sufficient to receive all the water from the boiler, a feed line connecting the tank with the boiler, a feed pump in the line, a valve in said line, a by-pass operative to return to the tank all water delivered by the pump in excess of the flow permitted, means controlling the opening of said valve in inverse proportion to the pressure of steam in the boiler, a return line connecting the boiler to the tank, a second valve in the return line, and means controlling degree of opening of the second valve in direct proportion to the pressure of steam in the boiler.

8. A control system for a waste heat boiler of the type supplied with heat at a temperature below that which would damage the boiler when dry, a tank of a size sufficient to receive all the water from the boiler, means for maintaining a minimum level of water in the tank, a feed line and a return line from said tank, a single valve casing receiving both of said lines, a third line connecting said valve casing with the boiler, means for forcing water through the feed line as permitted by the valve, a fourth line exposed to steam pressure in the boiler, a valve piston in the casing, and means responsive to the pressure of steam in the fourth line to shift the valve piston to connect the feed and third lines on decrease of said pressure below normal and to connect the return and third lines on an increase of said pressure above normal.

9. A steam generating system comprising a steam boiler supplied with heat from an internal combustion engine exhaust, a condensate tank large enough to receive all the water normally contained in the boiler, a feed water pump, a steam pressure operated valve between the pump and the boiler and adjusted to close upon an increase in boiler pressure above normal, a high water level control inserted in the feed line between the condensate tank and the boiler, and a steam pressure operated valve inserted in a return line between the boiler and the condensate tank and controlled by the steam pressure in the boiler so as to open upon an increase in boiler pressure above normal, whereby the water level in the boiler is automatically regulated to generate steam in accordance with the steam demand on the system.

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