Sept. 9, 1958 W. J. KINDERMAN 2,851,016

AUTOMATIC BOILER CONDITION MEASUREMENT AND CONTROL

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Fig. 1.

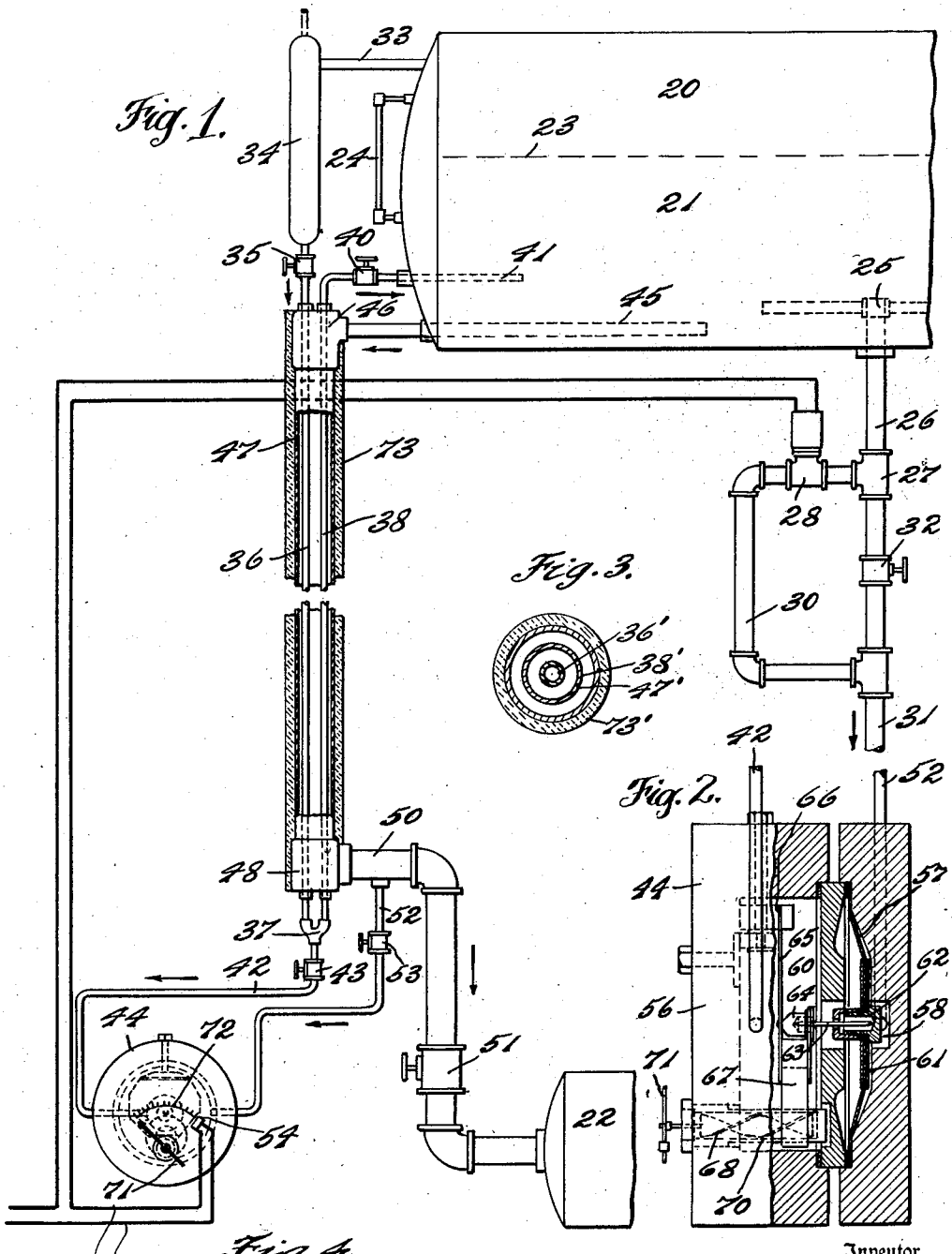


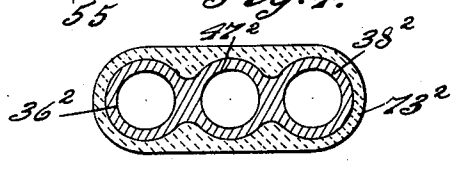

Fig. 3.




Fig. 2.




Fig. 4.




Inventor

Walter J. Kinderman

By

Attorneys

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# AUTOMATIC BOILER CONDITION MEASUREMENT AND CONTROL

Walter J. Kinderman, Philadelphia, Pa., assignor to Yarnall-Waring Company, Philadelphia, Pa., a corporation of Pennsylvania

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3 Claims. (Cl. 122—379)

The present invention relates to devices for measuring the content of solids in boiler water and particularly the concentration of soluble and dispersed solids, and for controlling the blowdown of a boiler in accordance with such concentration.

A purpose of the invention is to measure the pressure of a column of water sample withdrawn from the boiler and typical of the water in the boiler against a reference pressure, and preferably to control blowdown by the relative pressure.

A further purpose is to obtain the reference pressure from a column of condensate from the boiler.

A further purpose is to keep the water sample column and the condensate column in heat exchange relation and preferably insulate against heat losses from the columns.

A further purpose is to immerse one column in the liquid of the other column to maintain the same temperature in the columns.

A further purpose is to continuously circulate the sample water column from a lower point on the steam drum to the mud drum of the boiler.

A further purpose is to continuously circulate the condensate column from the steam space to the bottom of the column and then up through a reverse bend to the water space of the steam drum.

A further purpose is to maintain the temperatures in the two columns the same at the same levels with respect to the boiler, without necessarily maintaining the temperature the same at different levels.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate one only of the numerous embodiments in which my invention may appear, selecting the form shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

Figure 1 is a fragmentary diagrammatic partially sectional elevation of a boiler system to which the invention has been applied.

Figure 2 is a side elevation partly in axial section of a pressure gauge element involved.

Figure 3 is a horizontal section showing a variation of the piping arrangement between the boiler and the differential pressure gage.

Figure 4 is a view similar to Figure 3 showing a further variation.

At one time blowdown in a boiler was primarily designed to remove solids from accumulation in the boiler. With refinements in boiler water treatment, the practice has been adopted of maintaining flocculent insoluble deposits in suspension in the boiler and salts in solution, rather than to permit the deposit of hard scale. As such flocculent insoluble deposits and soluble salts build up in the water of the boiler, its density increases, and it has been found by the present inventor that the quantity of such flocculent insoluble deposits and salts can be indicated as a function of the density, and the control over the density can be very effectively used to control the



build-up of such deposits. Thus the invention is applicable as a more effective control of blowdown.

It is possible to establish a maximum permissible level for solubles and flocculent insoluble materials which is consistent with good boiler performance, and if blowdown occurs before this level is reached the maintenance of favorable boiler water conditions is assured.

I prefer to use pure water as a reference for comparing the density of the water burdened with solids. A very convenient source of such pure water is the boiler itself, by condensing steam.

In accordance with the invention, a reference head of pure water is continuously directed against one side of a pressure sensitive element while a slowly circulating similar head of boiler water is directed against the opposite side of the pressure sensitive element, the difference in the pressures corresponding to the differences in density in view of the fact that the heads are the same.

In order to make a proper correction for density differences due to different temperatures, it is best to maintain the two columns at the same temperature at corresponding heights, although the over-all temperature along each column can vary at the same rate from top to bottom. In order to do this, the two water columns are maintained in heat transfer relation, preferably one surrounding the other, and desirably with heat insulation around the columns to further equalize the temperature. Variations in the boiler level influence both heads uniformly, and therefore will cancel out with the exception of a very slight variation from the assumed constant head. If the heads themselves are large, this variation can be negligible.

In the case of the reference head of condensate it is necessary to provide for a return flow from the pressure-sensitive element to the boiler water. This is necessary in order to develop the true differential due to periodic variation in the boiler level and to prevent establishment of a differential head at the point at which the condensate forms in the boiler condensate column.

It is likewise desirable to have a continuous sampling of the boiler water by a slow circulation of the boiler water from a reference point in the steam drum down the boiler water leg to the mud drum of the boiler. Natural circulation is encouraged by cooling of the boiler water as it passes down the constant head tube and this circulation is suitably controlled by a valve located at a convenient point along the return connection to the boiler. The flow rate should be sufficiently low that the velocity will exert negligible effect on the pressure differential diaphragm, but should be rapid enough so that the sample obtained is a recent representative sample. The flow rate may be varied over a wide range without departing from these criteria.

Any desired pressure-sensitive element of adequate sensitivity may be used to measure the variation in density over a given head. Since the selected differential head is a calibration factor, the smaller the selected head the more sensitive the requirements of the pressure-sensitive elements. The indicator can be calibrated to indicate concentration in parts per million or any other unit of concentration starting at the bottom of the scale and moving upward. The range of desired operating concentration can be differentiated from the low and high limits in a manner similar to that employed in indicating high and low level as distinguished from normal level in a boiler stage. The control of the blowdown can be manual in response to the indications of the gauge, or it can be by limit alarm switches of the character which operate in response to boiler liquid level. It has been found from tests that a good and reliable response can be obtained and that the device can be operated for fully automatic blowdown.

Considering now the device as shown in Figure 1, a

boiler 20 there shown has a steam drum 21 and a mud drum 22 suitably interconnected as well known in the art. The water level 23 in the boiler is indicated on any suitable liquid level gauge diagrammatically illustrated at 24.

A blowdown connection is provided near the bottom of the steam drum at 25, leading off through a pipe 26 to a T 27 and then through a solenoid controlled spring closed blowdown valve 28 and thence through piping 30 to a suitable drain connection 31. The solenoid valve 28 is by-passed to the drain directly or through a heat exchanger by a normally closed manually operated valve 32.

A connection 33 is provided to the steam space of the steam drum, communicating through a condensing column 34 and normally open valve 35 to a pure water reference column 36 extending downwardly from the steam drum, terminating in a T fitting 37 at the bottom. From the T fitting 37 one recirculating pipe 38 extends upward close to the column 36 and returns through a normally open valve 40 to the boiler by a connection 41 located suitably in the water space of the steam drum at a lower point.

From the T 37 a pipe 42 leads off through a normally open valve 43 to one side of a differential pressure gauge 44, which according to certain aspects of the invention may be any suitable type of differential pressure gauge which has adequate sensitivity.

Thus it will be seen that there is a recirculating flow of condensate down the pure water column 36 and returning through the pipe 38 to the water in the boiler.

A connection 45 is led off from the water space of the steam drum at a level low enough to be representative of the blowdown and suitably at a point slightly below the blowdown connection 25. The connection 45 communicates through a fitting 46 with a tubular housing 47 which surrounds pipes 36 and 38 for the pure water. Housing 47 leads down to a bottom fitting 48 which is of L-form and communicates with pipe 50 leading through normally open valve 51 to the mud drum 22 of the boiler and continuing to circulate through the usual boiler connections.

From pipe 50 a pipe 52 leads off through a normally open valve 53 to the other side of the differential pressure gauge 44 as already described.

The differential pressure gauge is of the character which closes an electric switch 54 when the pressure difference indicates that the density of the water near the bottom of the boiler has risen high enough to require blowdown. The switch 54 either directly or through suitable relays closes an electric circuit 55 which energizes the solenoid valve 28 and opens the solenoid valve to permit blowdown. As soon as the condition of the water regarding solids drops to a suitable level in which blowdown is no longer required, the differential pressure gauge opens the electric switch 54 and the circuit 55 opens permitting the solenoid valve to close and stopping blowdown.

The differential pressure gauge may be of the type which is described and claimed in my U. S. Patent No. 2,509,644, granted May 30, 1950, for Differential Pressure Gauge. Figure 2 illustrates a device of this kind which has a housing 56 which mounts a flexible diaphragm 57, the diaphragm at the side 58 being exposed to the pressure of the pipe 52 and at the side 60 being exposed to the pressure of the pipe 42. Suitably in the middle of the diaphragm a rigid mounting 61 supports a socket 62 which receives and engages a pressure pin 63 which is engaged in a socket 64 on a leaf spring 65 mounted at 66 in the space 60. The leaf spring carries a suitably shaped horseshoe type magnet 67 which surrounds a spiral magnetizable armature 68 which extends between the poles of the horseshoe magnet and is rotatably mounted in a well 70 of nonmagnetic material. The helical armature 68 mounts a pointer 71 and the pointer, directly or through any suitable actuating mechanism, indicates the reading on a scale 72 and operates the switch 54.

It has been found that, using a commercial differential pressure gauge of the character shown in Figure 2, the water columns from the boiler should extend down approximately 25 or more feet, although it will be understood that the required height will vary with different differential pressure gauges.

It will be evident that on large power boilers the water columns may exceed 40 or 50 feet with corresponding increase in density differential provided the differential pressure gauge is calibrated to correspond. With the use of longer water columns, less sensitive differential pressure gauges may, of course, be used.

It will be understood, of course, that if the boiler is of a character in which continuous blowdown is used, the device of the invention may be operated either to control continuous blowdown or to operate an auxiliary supplemental blowdown valve where the continuous blowdown is adjusted so that it is not adequate to supply all of the blowdown requirements.

In operation it will be evident that in accordance with the device of the invention a continuous but slow stream of sample water is drawn down through the column within the casing 47, while a continuous but gradual stream of pure water is formed by condensation in the condensate column 34, flowing down through the column 36 and then back through the return pipe 38 to the water in the boiler. As this takes place, the sample water and the pure reference water are at each of the levels in heat transfer relation, and to insure that the respective columns are at the same temperature at the same level it is desirable to surround the casing 47 and the fittings 46 and 48 at the ends with heat insulation 73. Thus while there will be a temperature change from top to bottom, the temperature will be the same at any particular level in the various columns. The true density of the constant head of pure water is transmitted to the differential pressure instrument free from interference by the changing density of the boiler water.

The arrangement cancels out temperature effects and corresponding changes in density by maintaining temperature uniformity of the boiler water and pure water at any particular level.

In some cases it is preferable to arrange the piping somewhat differently from the arrangement shown in Figure 1. In Figure 3 the pure water pipe 36′, the recirculating pipe 38′ and the housing 47′ are respectively in telescoping relationship, one within another, with spaces between each larger pipe and the next smaller pipe. The housing is surrounded on the outside by heat insulation 73′.

Figure 4 shows a construction in which the pure water pipe $36^2$, the recirculating pipe $38^2$ and the housing $47^2$ are made in the form of tubes integrally joined at the side in a single extrusion, and surrounded by heat insulation $73^2$.

It will be evident that the invention can be applied whether the automatic blowdown feature is used or the device is used as an indicator with manual blowdown.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of my invention without copying the structure and method shown, and I therefore claim all such insofar as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In an instrument system for a boiler having a water level, walls forming a water sample column connected at the top of the water sample column to the boiler at a position corresponding to a low water level in the boiler and extending downward, walls forming a condensate

sample column similarly connected at the top of the condensate sample column to the boiler at a position corresponding to the low water level in the boiler and extending downward, walls forming a condensate supply column connected at the top of the condensate supply column to the steam space of the boiler and extending downward and the lower end of the condensate supply column and the lower end of the condensate sample column being connected, and a pressure gauge having a movable diaphragm, the water sample column and the condensate sample column being connected to opposite sides of the diaphragm adjacent the lower ends of such columns and indicating the differential pressure of the columns.

2. In an instrument system for a boiler having a water level, walls forming a water sample column connected at the top of the water sample column to the boiler at a position corresponding to a low water level in the boiler and extending downward, walls forming a condensate sample column similarly connected at the top of the condensate sample column to the boiler at a position corresponding to the low water level in the boiler and extending downward, walls forming a condensate supply column connected at the top of the condensate supply column to the steam space of the boiler and extending downward and the lower end of the condensate supply column and the lower end of the condensate sample column being connected, the water sample column, the condensate sample column and the condensate supply column all being in heat exchange relation with one another, and a pressure gauge having a movable diaphragm, the water sample column and the condensate sample column being connected to opposite sides of the diaphragm adjacent the lower ends of such columns and indicating the differential pressure of such columns.

3. In an instrument system for a boiler having a water level, walls forming a water sample column connected



at the top of the water sample column to the boiler at a position corresponding to a low water level in the boiler and extending downward, walls forming a condensate sample column similarly connected at the top of the condensate sample column to the boiler at a position corresponding to the low water level in the boiler and extending downward, walls forming a condensate supply column connected at the top of the condensate supply column to the steam space in the boiler and extending downward and the lower end of the condensate supply column and the lower end of the condensate sample column being connected, the water sample column, the condensate sample column and the condensate supply column being in heat exchange relation with one another, a pressure gauge having a movable diaphragm, the water sample column and the condensate sample column being connected to opposite sides of the diaphragm and the diaphragm being responsive to differential pressures of such columns, a blowdown valve connected to the boiler at a low water level in the boiler, and means operatively connecting the blowdown valve to the differential pressure gauge for operating the blowdown valve when the density of the sample water, as indicated by the pressure reaches a predetermined value.

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