United States Patent

Bell

[15] **3,687,115**

[45] **Aug. 29, 1972**

[54] **STEAM BOILERS**

[72] Inventor: **Alan Bell,** London, England

[73] Assignee: **Foster Wheeler Corporation,** Livingston, N.J.

[22] Filed: **Dec. 8, 1970**

[21] Appl. No.: **96,102**

[30] **Foreign Application Priority Data**

Dec. 12, 1969 Great Britain.....60,879/69

[52] **U.S. Cl.** .....**122/4 D,** 122/7 R

[51] **Int. Cl.**.....**F22b 1/02**

[58] **Field of Search**.....122/4 R, 4 D, 7 R

[56] **References Cited**

UNITED STATES PATENTS

2,818,049	12/1957	Blaskowski et al.	122/4
2,664,346	12/1953	Mayhew	122/4
3,080,855	3/1963	Lewis	122/4
3,254,634	6/1966	Yorkauf	122/7
3,431,892	3/1969	Godel	122/4

Primary Examiner—Kenneth W. Sprague

Attorney—John Maier, III, Marvin A. Naigur and John E. Wilson

[57] **ABSTRACT**

This invention relates to steam boilers which are fired by fluidized bed burners. Immersed in the fluidized bed are a number of banks of upright tubes, each bank of tubes extending between upper and lower headers, the banks being juxtaposed within the bed so that the tubes are substantially evenly distributed over the cross-sectional area of the bed. Preferably the headers radiate out from the axis of the bed and preferably the burners headers are positioned below the bed so that they are not subjected to the fierce temperatures existing within the bed. The arrangement according to the invention has inter alia the advantage that phase separation does not occur within those tubes used as evaporating tubes and so this reduces the danger of a tube burn out.

4 Claims, 5 Drawing Figures

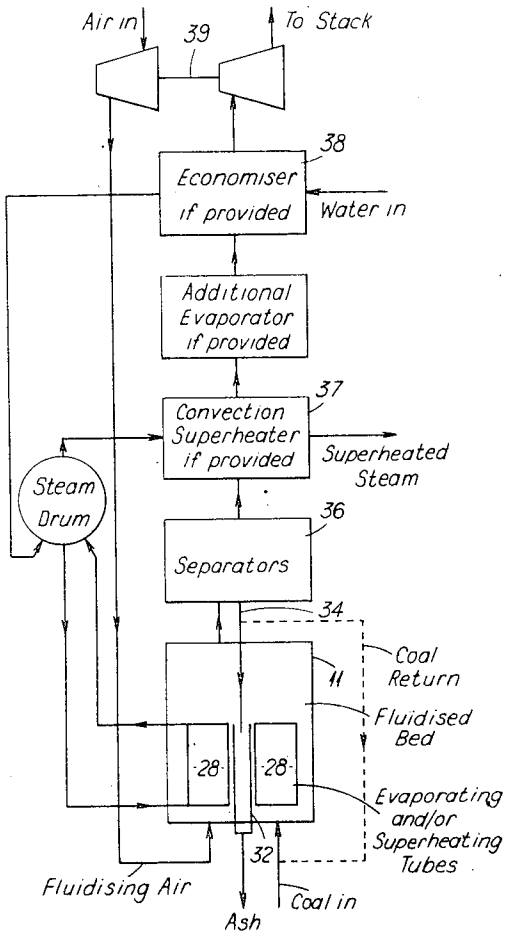
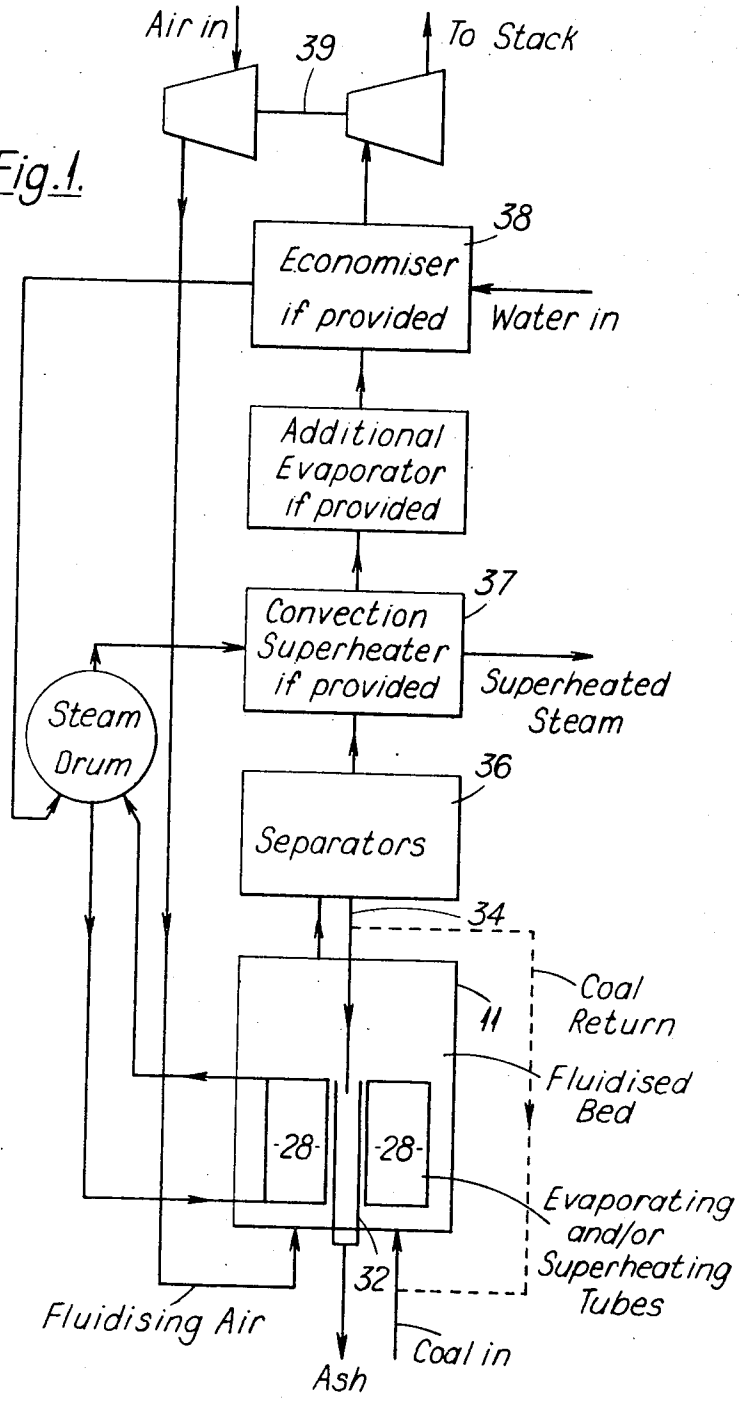


Fig. 1.


Air in
39
To Stack
38
Economiser if provided
Water in
Additional Evaporator if provided
37
Convection Superheater if provided
Superheated Steam
Steam Drum
36
Separators
34
11
Coal Return
Fluidised Bed
-28-
-28-
Evaporating and/or Superheating Tubes
32
Fluidising Air
Coal in
Ash

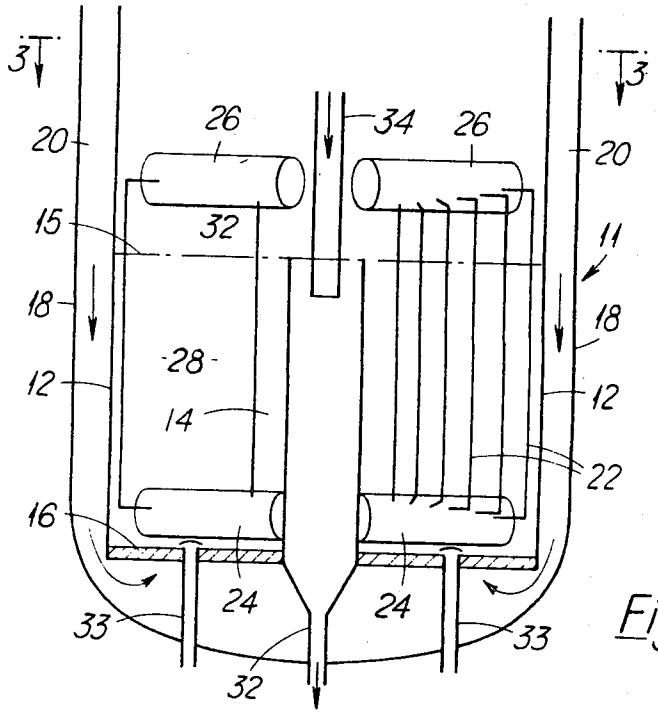

3
3
20
26
34
26
20
15
32
11
18
18
28
12
12
14
22
16
24
24
33
33
32

Fig. 2.

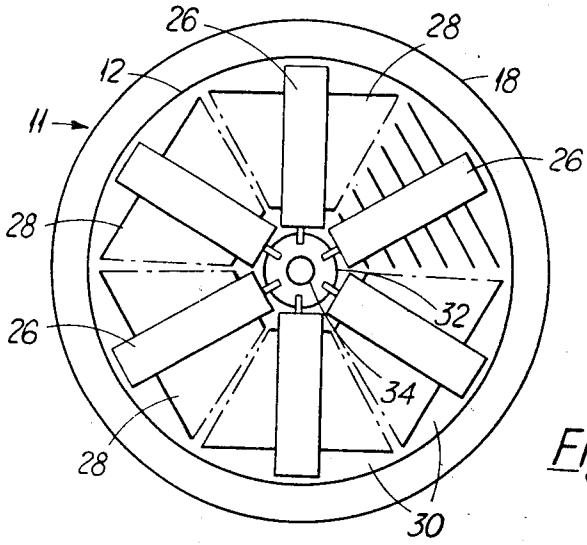

26
28
12
18
11
26
28
26
32
34
28
30

Fig. 3.

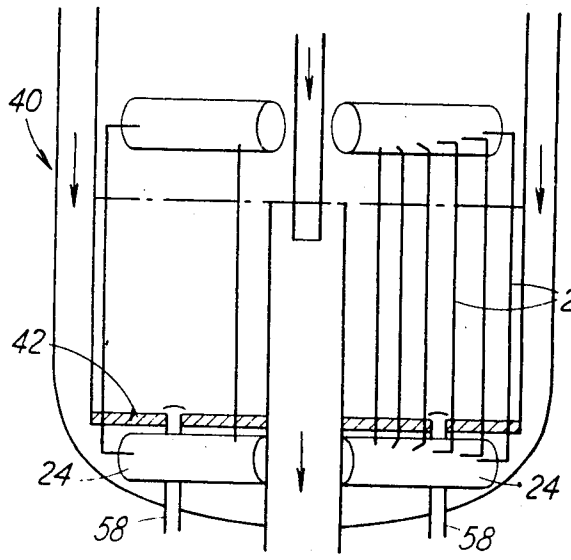


Fig. 4.

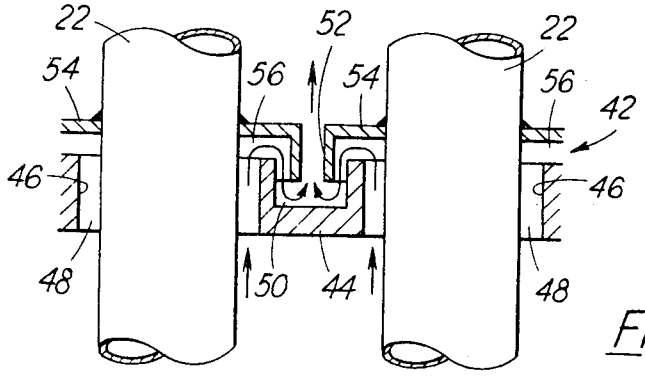


Fig. 5.

STEAM BOILERS

This invention relates to steam boilers which are fired by fluidized bed burners.

BACKGROUND TO THE INVENTION

The fluidized bed of a fluidized bed burner will normally comprise a loose bed of particles, most of which are ash particles and a few of which are coal particles, supported by a flow of combustion air which flows through the bed at sufficient velocity to support the particles. In practice the fluidized bed of particles behaves in a similar way to a boiling turbulent liquid. The coal particles burn in the air and, to support combustion, fresh coal particles are continuously added while, to maintain a substantially constant bed height, an overflow of ash particles is continuously withdrawn.

The heat produced by the burner can be used to produce steam in various ways. Preferably, however, steam raising tubes are immersed in the bed so as to exploit the very high heat transfer rates which can be achieved between the bed and the tubes. Also this arrangement ensures satisfactory cooling of the bed so as to prevent its reaching the ash fusion temperature.

BRIEF DESCRIPTION OF THE INVENTION

According to the invention the tubes immersed in the bed are substantially upright tubes extending between lower inlet headers and upper outlet headers, groups of tubes being connected between pairs of inlet and outlet headers to form a number of separate banks of tubes, these banks being juxtaposed within the bed so that the tubes are substantially evenly distributed over the cross-sectional area of the bed.

An important advantage of this arrangement is that, because the tubes are upright, phase separation does not occur in tubes in which evaporation is occuring and this reduces the danger of resulting tube burn outs which can occur when such tubes extend horizontally.

As noted above, the tubes can be distributed substantially evenly over the cross-sectional area of the bed because they are upright and this promotes an even temperature distribution throughout the bed.

Preferably the inlet and outlet headers are positioned so as to radiate outwardly, when seen in plan, from a central point of the bed. Conveniently the bed can be positioned within a cylindrical vessel and in this case the bed will be circular in cross-section and the inlet and outlet headers can radiate radially out from the center or axis of the vessel.

According to a preferred embodiment of the invention, the banks of tubes are, when seen in plan, of truncated sector shape and these banks are fitted within the bed so that the individual tubes are substantially evenly distributed over the cross-sectional area of the bed.

The banks of the tubes can all consist of evaporating tubes either when no superheater or reheater is required or a superheater or reheater is provided and is swept and heated by the passage over it of the hot gases from the bed. Alternatively one or more of the banks of tubes within the bed can consist of steam heating, i.e. superheating or reheating tubes while the remaining banks consist of evaporating tubes.

The tubes in the banks extend generally upright. The ends of the tubes may, however, be bent from the upright so as to connect them to the inlet and outlet headers.

According to one embodiment of the invention, the bed is defined within an inner cylindrical vessel which in turn is surrounded by an outer cylindrical pressure vessel. The two vessels define between themselves an annular passage and the fluidizing air passes down this passage before travelling up through the bed. This arrangement has the advantage that when, the fluidizing air is at a pressure above atmospheric pressure, the inner vessel, which is subjected to the high temperatures of the bed, has only to withstand the pressure drop experienced by the air in passing through the bed, while the outer vessel, which is not subjected to high temperature, can readily be built to withstand the excess internal pressures.

As noted above an overflow of particles is continuously removed from the bed to keep the bed height constant. With the arrangement according to the invention when the tubes immersed within the bed are upright, the outlet for these particles can be an open-topped cylinder, tube or funnel positioned centrally between all of the tubes, this outlet extending downwardly out of the bed. This central arrangement for the ash outlet, assists in maintaining a substantially even bed.

If desired the lower headers can be positioned below the distribution plate with the upright tubes extending through the plate so that the headers are not subjected to the very fierce temperatures within the bed. With this arrangement, the distribution plate through which the fluidizing air is supplied to the bed can comprise a plate having circular cut-outs through which the tubes extend, the cut-outs being of slightly larger diameter than the outside diameter of the tubes so as to leave annular passages through which the fluidizing air passes. Covering these annular passages and fixed around the tubes may be inverted cups or circular flanges which distribute the air and prevent ash from falling back down the annular passages when the supply of fluidizing air is stopped.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic flow diagram of a steam boiler according to the invention;

FIG. 2 is a sectional elevation through a fluidized bed steam boiler according to the invention;

FIG. 3 is a plan view of the boiler taken on the line 3—3 of FIG. 2;

FIG. 4 is an elevation similar to FIG. 2 of a modified boiler according to the invention; and

FIG. 5 is an enlarged cross-sectional detail of the boiler shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The steam boiler 10 shown in FIGS. 1 and 3 of the drawings has a fluidized bed burner 11. This burner 11 comprises an inner cylindrical vessel 12 in which the fluidized bed 14 is defined, the upper level of the bed being at 15. The base of the vessel 12 is closed by a perforated distribution plate 16 which distributes the fluidizing air evenly over the bed. Surrounding the inner vessel 12 is an outer cylindrical pressure vessel 18 and between the vessels 12 and 18 is defined an annular

passage 20. Through this passage, the fluidizing air passes downwardly to the plate 16. In the case where this air is at a pressure above atmospheric, the outer vessel 18 is designed to resist this excess pressure while the inner vessel 12 has only to resist the low pressure drop of the air across this plate 16 and bed 14. The inner vessel 12 is, however, exposed to the high temperature of the bed 14 whereas the outer vessel 18 is not subjected to these high temperatures.

Positioned within the bed 14 are a large number of substantially upright tubes 22 which extend between lower inlet headers 24 and upper outlet headers 26. These headers extend radially of the circular cross-section of the bed 14 and each outlet header is positioned below an inlet header. The tubes 22 are arranged so that groups of tubes are connected between an inlet header and the outlet header positioned above it so as to form a number of banks 28 of tubes. As shown best in FIG. 3, these banks are of generally truncated sector-shape and they are juxtaposed so that the tubes cover the whole area of the bed and the individual tubes 22 are substantially evenly distributed over the cross-sectional area of the bed.

The banks 28 are shown in FIG. 2 as leaving segments 30 not containing tubes and these segments can if desired be blanked off, or can contain tubes 22. Alternatively, these segments 30 can be suitably baffled and be used for the passage of the fluidizing air instead of the passage 20.

In the embodiments shown there are six banks 28 of tubes. There could, however, be more or less, the exact number and their shape and disposition depending upon the shape and general design of the bed 14.

In order to keep the bed 14 at a constant height, a central open-topped tube 32 is provided which acts as an overflow or outlet. This tube extends through the plate 16 and out through the base of the vessel 18 to an ash hopper (not shown). A constant stream of ash spills over into this tube 32 and so retains the bed at the constant height since fresh coal is supplied through capped inlets 33.

The hot fluidizing air leaving the bed will normally pass to dust separators 36 to remove entrained particles and any such particles removed can conveniently be fed into the tube 32 by an outlet tube 34. If these entrained particles contain significant proportions of fine coal, they can be recirculated to the bottom of the bed.

Each of the banks 28 can consist of evaporating tubes. In this case, there may be no superheater or alternatively a convection type superheater 37 can be positioned in the air flow downstream of bed, e.g. above it. Alternatively, some of the banks 28 can be superheating tubes. For example, two diametrically opposite banks can be of superheating tubes while the remaining four are of evaporating tubes. In this case, additional superheating and/or evaporating and/or economizing tube surface may be provided above the bed. Thus, it can be seen how the design according to the invention allows very flexible use of the tubes 22.

The vessel 12 can be lined with water tubes consisting further evaporating surface if desired. Additionally, an economizer 38 can be provided downstream of the bed and the air fed to the bed can be preheated by the exhaust air. All these features do not form part of the inventive concept and so do not need to be described in detail.

As best shown in FIG. 1, the supply of fluidizing air can be provided by means of a turbine arrangement 39 in which air is pressurized by means of a turbine linked to another turbine driven by the hot spent combustion gases on their way to a stack (not shown).

The upright disposition of the tubes 22 prevents phase separation between water and steam in those tubes used for evaporation and this reduced the risks of tube failure.

Another feature of the boiler 10 is the central overflow tube 32 which promotes even off-take of the excess ash and consequently assists in maintaining even fuel distribution and bed temperatures.

The boiler 40 shown in FIGS. 4 and 5 is generally similar to the boiler 10 shown in FIGS. 1 to 3 with the exception that the distribution plate 42 is of different form. Apart from this plate 42 the other parts of the boiler are similar to the corresponding parts of the boiler 10, and are given the same reference numerals and will not be described in detail.

In the boiler 40 the plate 42 is positioned above the inlet headers 24 and the upright tubes 22 extend through the plate 42. This is shown in more detail in FIG. 5.

As shown therein the plate 42 comprises a lower plate 44 having circular cut-outs 46 through which the tubes 22 extend and which are of a diameter larger than the tubes so as to leave annular passages 48 between the tubes 22 and the lower plate 44. The lower plate 44 also has annular grooves 50 in its upper surface which coaxially surround the cut-outs 46. Projecting into these grooves 50 are the rims 52 of inverted cups 54 which are themselves fixed to the tubes 22. The arrangement is such that passages 56 in communication with the passage 48 are provided between the cups 54 and the surface of the grooves 50. Therefore the fluidizing air can pass through these passages 48 and 56 to fluidize the bed.

It will be noted that the cups 54 are fixed to the tubes 22 while the plate 44 is not. There are therefore no problems of differential expansion between the tubes 22 and plate 44.

In order to introduce fresh fuel into the bed, capped pulverized fuel inlets 58 are provided (FIG. 4).

The additional advantages of the boiler 40 over those of the boiler 10 are that the lower headers 24 which are relatively large metal masses outside the bed and so are not subjected to the very high temperatures existing within the bed. Also the bends at the lower ends of the tubes 22 where the tubes are not upright, are outside the bed and consequently not susceptible to overheating due to local deficiencies of water cooling. Further, the design of the plate 42 avoids the fallen out ash clogging the passages 48 and 56 in the plate 42 when the supply of fluidizing air is turned off since most of the ash will deposit on the top surfaces of the cups 54.

Although the terms water and steam have been used herein, these terms are to be construed as covering any suitable liquid and its vapor unless the context specifically requires otherwise.

A lattitude of modification, change and substitution is intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.

I claim:

1. A fluidized bed burner steam boiler comprising

a fluidized bed of ash and combustible particles, means for fluidizing said particles and causing combustion of said combustible particles,

immersed within said bed a number of banks of substantially upright tubes of the type chosen from evaporating tubes and steam heating tubes,

an upper and a lower header for each of said banks of tubes, said tubes of each bank extending between said upper and lower headers,

said banks being juxtaposed within said bed so that said tubes are substantially evenly distributed over the cross-sectional area of said bed, and

an air distribution plate defining the base of said fluidized bed, and in which said lower headers are positioned below said air distribution plate, said upright tubes extending through said distribution plate.

2. A steam boiler according to claim 1 in which said distribution plate comprises a plate, circular cut-outs in said plate through which said upright tubes extend, annular passages being defined between said tubes and said cut-outs for the passage of fluidizing air to said bed, and annular plates fixed to said tubes and covering said annular passages whereby said fluidizing air passing through said passages is distributed and ash is prevented from falling back into said passages when the supply of fluidizing air is stopped.

3. A fluidized bed burner steam boiler comprising

a cylindrical vessel,

a distribution plate extending across said cylindrical vessel and defining with said vessel a region in which ash and combustible particles can be fluidized, means for supplying fluidizing air, said air being arranged to pass upwardly through said distribution plate to fluidize said particles,

a number of outlet headers positioned above said bed, said headers when viewed in plan being arranged so as to radiate outwardly from the axis of said cylindrical vessel, a number of inlet headers positioned below said outlet heads and also arranged so that, when viewed in plan, they radiate outwardly from said axis of said cylindrical vessel,

banks of substantially upright tubes extends between said inlet and outlet headers, said tubes being of a type chosen from evaporating tubes and steam heating tubes,

said banks of tubes being of truncated sector shape, when viewed in plan and being arranged so that said tubes are distributed substantially evenly over the cross-sectional area of said bed,

a central upright open-topped tube extending up within said bed centrally of said banks of tubes, said open-topped tube constituting an outlet into which excess particles are arranged to overflow when said bed is fluidized so as to maintain a constant bed height, and

means for supplying fluid chosen from steam and water to said tubes for heating.

4. A steam boiler according to claim 3 in which said lower headers are positioned below said distribution plate, said upright tubes extending through said distribution plate.

* * * * *