United States Patent

Foldes et al.

[15] **3,659,559**

[45] **May 2, 1972**

[54] FLUIDISED BED BURNER CONTROL

[72] Inventors: **Gabriel F. Foldes**, Banstead; **Peter W. Neve**, Biggin Hill; **Peter J. Corbridge**, London, all of England

[73] Assignee: **Foster Wheeler Corporation**

[22] Filed: **June 22, 1970**

[21] Appl. No.: **48,221**

[52] **U.S. Cl.** ..... **122/4 D**, 34/57 R, 110/28 J

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

[58] **Field of Search** ..... 122/4, 4 D; 110/28, 28 J; 34/57 R

[56] **References Cited**

UNITED STATES PATENTS

3,361,539	1/1968	Pyzel	34/57 X
3,101,697	8/1963	Hunter	122/4
2,818,049	12/1957	Blaskowski et al	122/4 X

FOREIGN PATENTS OR APPLICATIONS

776,791	6/1957	Great Britain	122/4

Primary Examiner—Kenneth W. Sprague

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

[57] **ABSTRACT**

There is described herein a fluidised bed burner for a steam boiler. It has been found to be difficult to control the operation of such burners in response to varying heat outputs so as to meet steam load demands. According to the invention this control is achieved by providing an overflow take-off for the bed particles which is adjustable in relation to the height to the bed so that the height and accordingly volume of the bed can be adjusted. According to a preferred feature of the invention the cross-sectional area of the bed increases with increasing bed height. This provides the advantages that a relatively fine adjustment of the output of the bed is possible a low load, and the velocity of the fluidising gases at the top of the bed are relatively slow and so relatively fed particles are entrained and removed from the bed.

11 Claims, 5 Drawing Figures

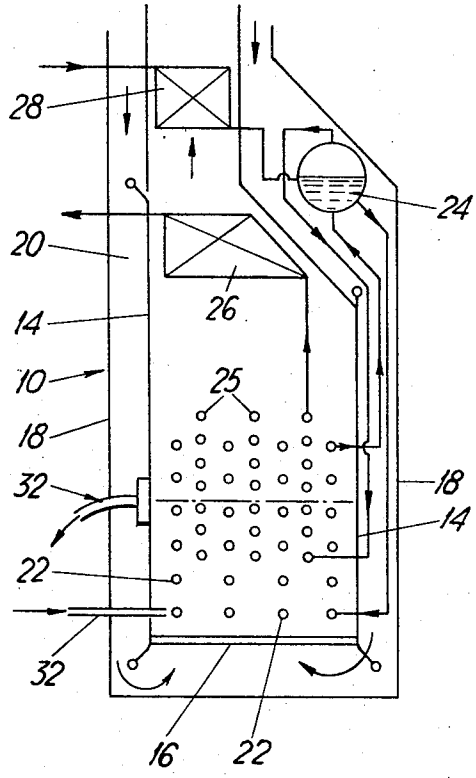


Fig. 1.

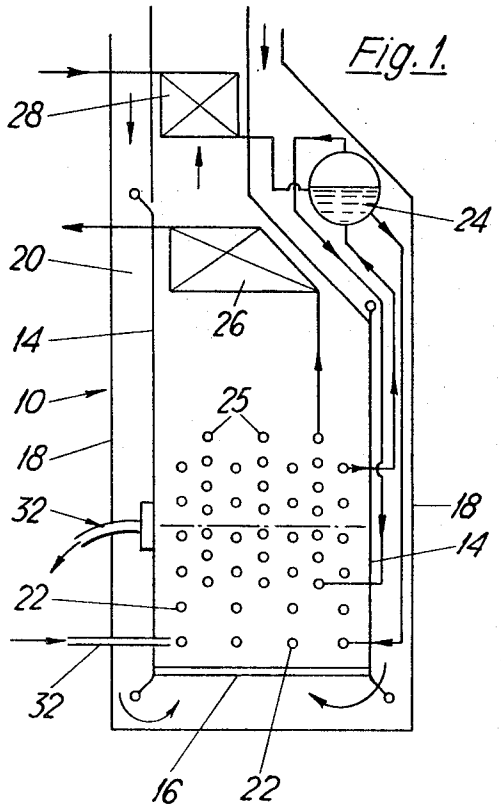


Fig. 5.

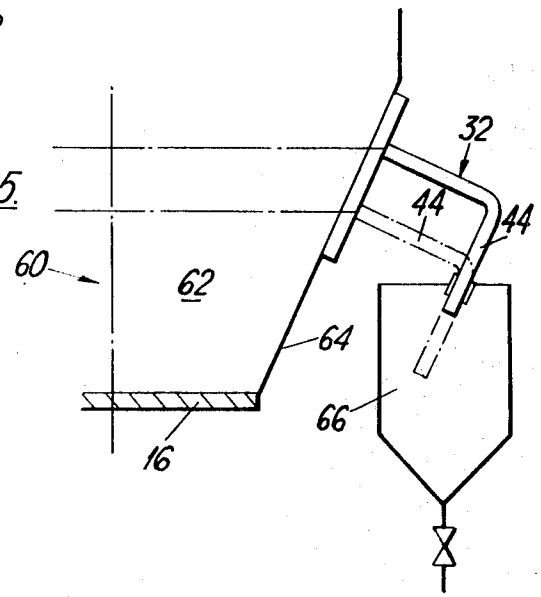


Fig. 2.

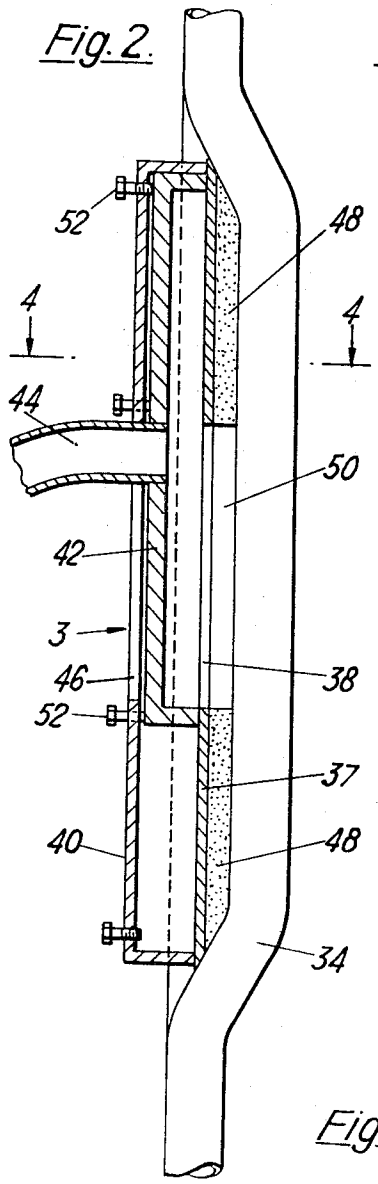


Fig. 3.

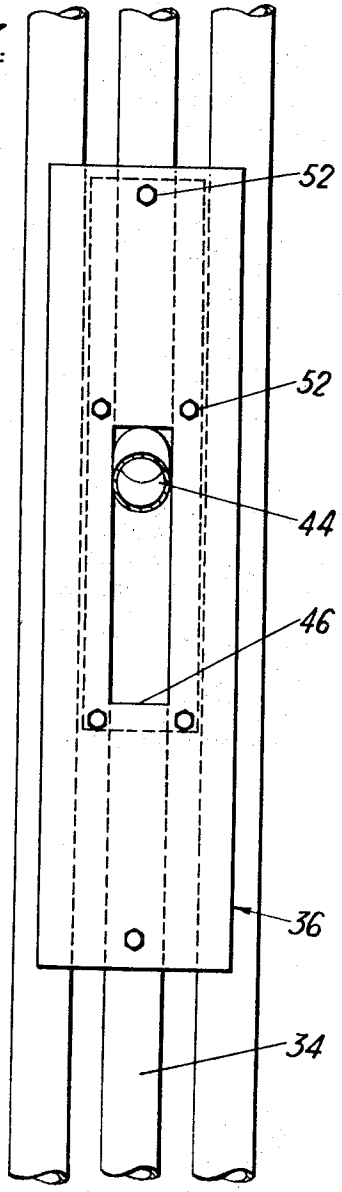
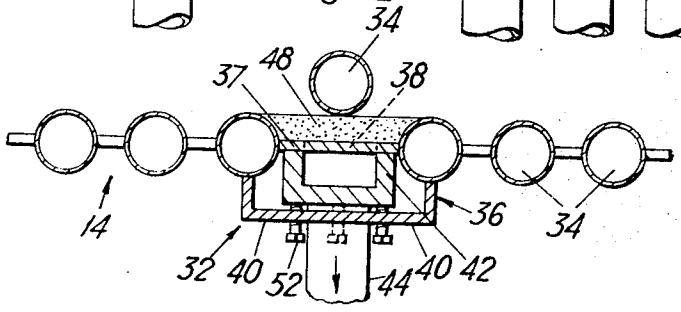


Fig. 4.



FLUIDISED BED BURNER CONTROL

This invention relates to a fluidized bed burner and is particularly concerned with a fluidized bed burner which is suitable for use with a steam boiler installation.

BACKGROUND OF 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 granules, 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 keep the bed height substantially constant, an overflow of particles is continuously withdrawn.

The heat produced by the burner can be used in the production of steam in various ways. One way is to pass the hot gases leaving the bed over tube banks. A preferred way is, however, to immerse at least the steam raising tubes in the bed itself since then very high heat transfer rates can be achieved, and satisfactory cooling of the bed can be achieved so that the bed does not reach the ash fusion temperature.

The control of combustion to suit varying steam demands and also the control of superheat temperature is difficult and it is, therefore, an object of this invention to provide a simple way of controlling the bed height and accordingly heat output so as rapidly to meet load demands.

THE INVENTION

According to this invention there is provided a fluidized bed burner having an overflow take-off for bed particles, the level of this take-off being variable in relation to the height of the bed so that when the bed is in operation, as the level of the take-off is adjusted, more or less particles overflow from the bed until the height of the bed adjusts itself to the new level of the overflow take-off.

Such an arrangement is very simple and effectively and rapidly controls the bed height. Thus for example, to reduce the overall heat output from the bed, its height can be lowered, and accordingly the bed volume reduced, by lowering the take-off and then excess particles rapidly overflow through this until the bed height again becomes level with the take-off and stabilizes itself.

This adjustment of the height of the bed can be exploited in a number of ways. Thus, if a bank of steam raising and/or superheating and/or reheating tubes are positioned so as to be at least partially immersed in the fluidized bed, when this is in operation the adjustment of the height of the bed can also vary the amount of heating surfaces immersed in the bed and accordingly vary the relative rate of heat transfer to the various surfaces. Alternatively the relative heat pick-up of tube surface immersed in the bed and convection tube surface heated by the hot gases from the bed can be altered; thus the superheat or reheat temperature can be controlled with load.

A further advantage of the provision of a take-off which is adjustable for height is that one can compensate for any approximations or inaccuracies in the design of the burner.

The adjustment of the heat output and accordingly bed height and also the amount of excess air is particularly critical at low loads. Therefore, in accordance with a preferred embodiment of the invention the area in which the bed is confined increases with increasing height. In this way a small change in bed height at low heights makes a relatively small change in bed volume whereas at higher bed heights the same height change makes a much larger increase in bed volume. With burners beds having constant cross-section it is almost impossible to adjust the amount of excess air without either blowing a large number of smaller particles out of the bed or failing to fluidize larger particles. With burners according to this preferred embodiment where the bed cross-section increases with height, adjustment of the proportion of excess air causes only a relatively small adjustment to the bed height and, because the air moves faster at the bottom than at the top of the bed, the problem of retaining smaller particles in the bed and fluidizing larger particles is considerably reduced.

Additionally, the shaping of the bed in this way has the advantage that fluidizing air velocity is lower at the top surface of the bed than it is lower down the bed. Therefore, while the air velocity at the base of the bed will be sufficiently fast to fluidize the particles and ensure very thorough mixing, the air velocity at the surface of the bed can be much less and be such that relatively few particles are entrained and so there is a relatively low loss of fuel particles and entrained particles from the bed and so their later separation is simpler. This can be particularly important when the bed is operated at a pressure above atomospheric pressure where the combustion gases are fed for expansion to a gas turbine and must, therefore, be relatively free from entrained particles.

The adjustment of the overflow take-off can be made in any convenient way. According to one arrangement an upright slot is formed in the wall of the burner and a slidable plate which covers the slot in all positions is positioned over this slot and has in it an outlet nozzle, the level of which, as the plate is slid up or down over the slot, determines the overflow level and height of the bed. To keep the sliding joint clean and ash-free, the air pressure outside the burner wall can be kept higher than that inside the bed. This can readily be achieved by causing the combustion gas to flow down around the outside of the burner wall and then up through the porous base of the bed and the bed itself.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be illustrated by way of example with reference to the accompanying diagrammatic drawings in which:

FIG. **1** is a general diagram of a fluidized bed burner in accordance with the invention forming part of a steam boiler;

FIG. **2** is an enlarged detail section of the overflow take-off;

FIG. **3** is a detail view in the direction of the arrow **3** of FIG. **2**;

FIG. **4** is a section taken on the line **4—4** of FIG. **2**; and FIG. **5** is a diagrammatic sectional detail of a modified burner in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The fluidized bed burner **10** shown in FIG. **1** comprises a bed **12** of fluidized particles defined by water-tube walls **14** consisting, for example, of finned tube panels. The base of the bed has a porous air-distributor **16** and the walls **14** are surrounded by an outer shell **18** which defines with the walls **14** an annular inlet air passage **20**.

Immersed in the bed **12** are steam raising tubes **22** through which water circulates to and from a steam and water drum **24**. This may be situated either inside or outside the outer shell **18**. Steam separated in the drum pases to primary superheater tubes **25** at least part of the lengths of which is immersed in the bed **12**. Thereafter the steam pases to a secondary connection superheater **26** suspended in the hot combustion products above the bed. Feed water is fed to the drum through an economizer **28** positioned above the superheater. Although a reheater is not shown, one could be provided, either above and / or in the bed.

Upon leaving the economizer the combustion products pass to separators (not shown) for the removal of entrained particles and, in the case where the burner **10** operates at a pressure substantially above atmospheric, to a gas turbine (not shown) where the gases expand and in turn drive a compressor which supplies fresh combustion air to the passage **20**.

The bed consists predominantly of ash particles and a few coal particles. Fresh coal particles are supplied through an inlet **30** while an overflow of particles leaves through an overflow off-take **32** whose level is, in accordance with the invention, adjustable. The off-take **32** will now be described in more detail.

The construction of the off-take **32** is shown in detail in FIGS. **2** to **4**.

An opening in the wall **14** is made by setting one of the tubes **34** of the wall into the bed **12** out of alignment with the other tubes. Over the opening so formed is positioned a casing **36** comprising a front plate **37** with an outlet slot **38** and a rear plate **40**. Within the casing **36** a sliding plate **42** is slidable. The latter carries an outlet nozzle **44** which in turn projects through a slot **46** in the rear plate **40**.

Between the front plate **37** of the casing **36** and the tube **34** is provided a layer **48** of heat resisting insulating material to protect the off-take **32** an outlet **50** being left in this layer in alignment with outlet slot **38**.

Spring loaded pins **52** pass through the rear plate **40** into contact with the sliding plate **42** so as to urge this into sealing engagement with the front plate **37**.

The operation of the off-take **32** is very simple. By moving the sliding plate **42** up or down within the casing **36**, the level of the outlet nozzle is varied. The particles within the fluidized bed act similarly to a liquid and overflow through the outlet **44** and the top level of the bed rapidly assumes the level of the outlet **44** once its position has been adjusted.

Although the burner **10** is shown with only one off-take **32** it can, and often will, have more than one spaced around the walls **14**.

In order to keep the sliding plate clean and ash free, it is preferred that the pressure outside the bed **12** be higher than that existing in the bed so that air infiltrates through the off-take into the bed. This is achieved by the arrangement shown in FIG. **1** where the air supply to the bed passes down the passage **20**, since there is some pressure drop as the air passes through the porous air-distributor **16** and so the pressure in the passage **20** is slightly in excess of the pressure within the bed **12**.

By adjusting the height of the bed **12** with the off-take **32** the volume of the bed and accordingly its heat output can be varied. In addition one can markedly adjust the heat transfer to the tubes **22** and **25** if, by varying the height of the bed, more or less of the surface of the tubes is immersed in the bed **12**. Further the adjustment of the level can be used to alter the relative heat transfer between heat transfer surfaces immersed in the bed and convection heat transfer surfaces over which the hot gases from the bed pass. Thus, one has some control over the superheat and/or reheat temperature.

A further way in which the adjustment of the bed height can be used is to compensate for inaccuracies or approximations in the original design of the bed.

A modified burner **60** is shown in FIG. **5**. This burner has a bed **62** defined by side walls **64**. These walls have an inverted frusto-conical shape at least over the height of the bed so that the cross-sectional area of the bed increases with height. The bed **62** shown in FIG. **5** is circular in plan. It could, however, be square or rectangular in which case the walls **64** could define a frusto-pyramidal shape. In addition where the bed is square or rectangular only an opposed pair of walls might be included while the other opposed pair are vertical or solely one wall might be inclined. What is essential, however, is that the cross-sectional area of the bed should increase with height in some way or another.

The base of the bed has a porous distributor **16** and at least one off-take **32** similar to that described in connection with FIGS. **2** to **4**. The outlet nozzle **44** of the off-take leads into a hopper **66** for the collection and disposal of the ash and possible separation of any coal particles for return to the bed.

The provision of a bed with the shape shown in FIG. **5** together with the take-off **32** the level of whose nozzle **44** is adjustable, has a number of advantages. Thus, at lower loads and accordingly lower bed heights, a finer adjustment of the heat output is given as compared with a coarser adjustment at higher loads. In addition, one can adjust the proportion of excess air without this making a relatively large variation in bed height. Further, the shape of the bed has the advantage that the combustion products leaving the top of the bed are travelling at a much lower velocity than the combustion air at the base of the bed which must of course be sufficient to give good fluidization. Therefore, relatively few particles are entrained with the gases leaving the bed and this simplifies their separation.

Although the terms water and steam are used herein, they are intended to embrace the use of any suitable liquid and its vapor unless the particular content requires otherwise.

A latitude 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 comprising wall means defining a bed region in which combustible articles are arranged to be fluidized and burnt to give ash particles, a porous distributor defining a base for said bed region, means for supplying a fluidizing gas to and through said distributor to fluidize said combustible and ash particles, means for feeding fresh combustible particles to said bed region, and means for continually withdrawing excess particles, said means comprising at least one overflow take-off, vertically adjustable in relation to the height of said bed region, whereby during operation of said burner vertical adjustment of said level of said take-off causes more or less excess particles to overflow from said bed region so varying the height of said bed region.

2. A burner according to claim **1** in which said wall means define a cross-sectional area which increases with increasing height of said bed region.

3. A burner according to claim **2** in which said wall means have the shape of an inverted truncated cone.

4. A fluidized bed burner comprising wall means defining a bed region in which combustable articles are arranged to be fluidized and burnt to give ash particles, a porous distributor defining a base for said bed region, means for supplying a fluidizing gas to and through said distributor to fluidize said combustible and ash particles, means for feeding fresh combustible particles to said bed region, and means for continually withdrawing excess particles, said means comprising at least one overflow take-off, an upright slot in said wall means, a slidable plate covering said slot and being slidable up and down relatively to said slot, and an outlet nozzle through said plate constituting said overflow take-off, whereby as said sliding plate is raised or lowered relatively to said slot, the level of said take-off is correspondingly raised or lowered to cause more or less excess particles to overflow from said bed region so varying the height of said bed region.

5. A burner according to claim **4** further comprising a spaced outer wall means surrounding said wall means and defining therewith a passage for the supply of said fluidizing gas to said distributor, whereby the pressure of said gas in said passage is lighter than the pressure within said wall means and said sliding plate and slot are kept substantially ash-free.

6. In a fluidized bed burner comprising wall means defining a bed region, a porous distributor defining a base for said bed region, and means for supplying fluidizing gas through said distributor to fluidize particles in said bed region, the improvement comprising providing an overflow take-off from said bed region through said wall means, the level of said overflow take-off being adjustable in relation to the height of said bed region, whereby as the level of said take-off is adjusted, more or less particles are arranged to overflow from said bed until the height of said bed adjusts itself to the new level of said overflow take-off.

7. In a burner according to claim **6**, the shaping of said wall means so that the cross-sectional area defined by said wall means increases with increasing height.

8. A steam boiler including a fluidized bed burner comprising wall means defining a bed region in which combustible articles are arranged to be fluidized and burnt to give ash particles, a porous distributor defining a base for said bed region,

means for supplying a fluidizing gas to and through said distributor to fluidize said combustible and ash particles, means for feeding fresh combustible particles to said bed region, and means for continually withdrawing excess particles, said means comprising at least one overflow take-off, vertically adjustable in relation to the height of said bed region, whereby during operation of said burner adjustment of said level of said take-off causes more or less excess particles to overflow from said bed region so varying the height of said bed region, and heat exchange means in which water is converted to steam by heat provided by said burner.

9. A steam boiler according to claim 8 in which said wall means define a cross-sectional area which increases with increasing height of said bed region.

10. A steam boiler including a fluidized bed burner comprising wall means defining a bed region in which combustible articles are arranged to be fluidized and burnt to give ash particles, a porous distributor defining a base for said bed region, means for supplying a fluidizing gas to and through said distributor to fluidize said combustible and ash particles, means for feeding fresh combustible particles to said bed region, and means for continually withdrawing excess particles, said means comprising at least one overflow take-off, adjustable in relation to the height of said bed region, whereby during operation of said burner adjustment of said level of said take-off causes more or less excess particles to overflow from said bed region so varying the height of said bed region, and heat exchange tubes which are positioned so as to be a least partially immersed in said bed region, said tubes being either steam raising, superheating or reheating tubes, whereby adjustment of the level of said take-off will, when the boiler is in operation, vary the amount of tube surface within, said bed region.

11. A steam boiler including a fluidized bed burner comprising wall means defining a bed region in which combustable articles are arranged to be fluidized and burnt to give ash particles, a porous distributor defining a base for said bed region, means for supplying a fluidizing gas to and through said distributor to fluidize said combustible and ash particles, means for feeding fresh combustible particles to said bed region, and means for continually withdrawing excess particles, said means comprising at least one overflow take-off, adjustable in relation to the height of said bed region, whereby during operation of said burner, adjustment of said level of said take-off causes more or less excess particles to overflow from said bed region so varying the height of said bed region, and heat exchange means in which water is converted to steam by heat provided by said burner, said heat exchange means comprising at least one bank of tubes at least partially positioned within said bed region and at least another bank of tubes positioned so as to be heated by convection by the passage of gases from said bed region over it, whereby the adjustment of the level of said take-off will vary the heat pick-up of said heat bank positioned in said bed region relative to that of said tube bank heated by convection.

* * * * *