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[54] **FLUIDISED BED COMBUSTION**

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[51] **Int. Cl.²**..... **F22B 1/02**

[58] **Field of Search**..... 110/8 R, 28 J; 122/4 D

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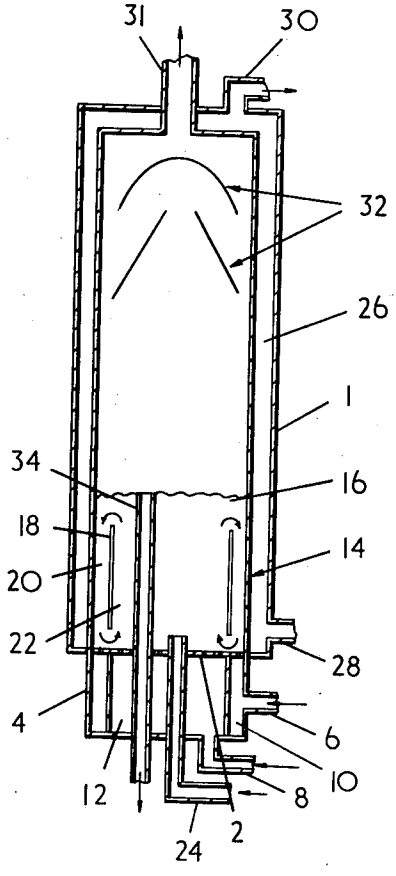
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[57] **ABSTRACT**

A method for burning a fuel involves the use of a fluidised combustion bed in which the fuel is burnt and a fluidised heat transfer bed in which heat generated by the combustion bed is transferred to a heat exchange fluid. Hot material from the combustion bed is circulated to the heat transfer bed and returned to the combustion bed and to this end the heat transfer bed is located adjacent the combustion bed. The rate of the circulation determines the heat output and this rate can be varied by varying the fluidising velocities in the two beds. Both beds are conveniently contained within one body and may be divided from each other by a division which allows of the circulation referred to above.

18 Claims, 3 Drawing Figures



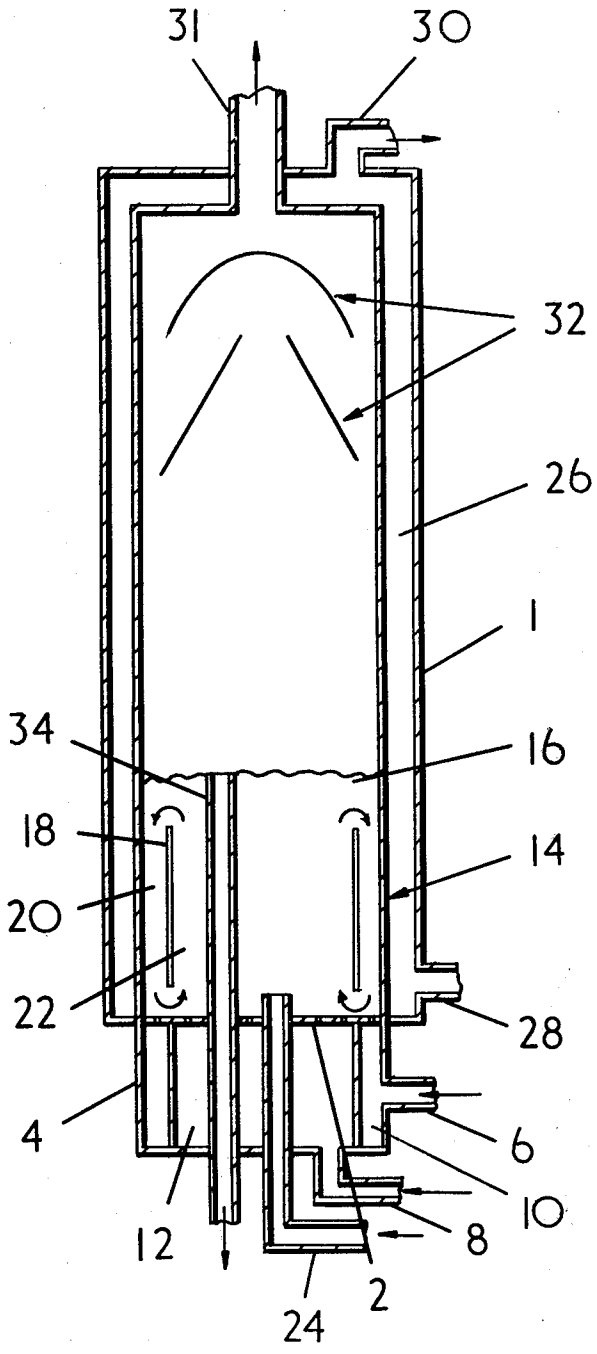


FIG.1.

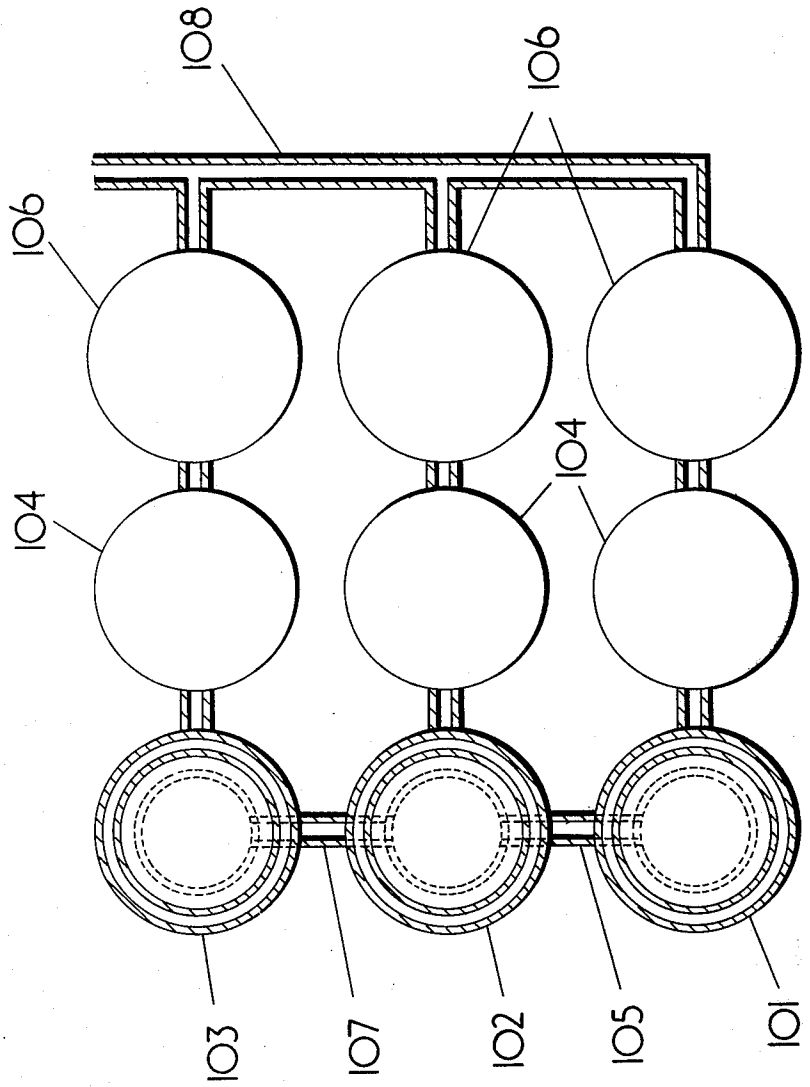


FIG.2.

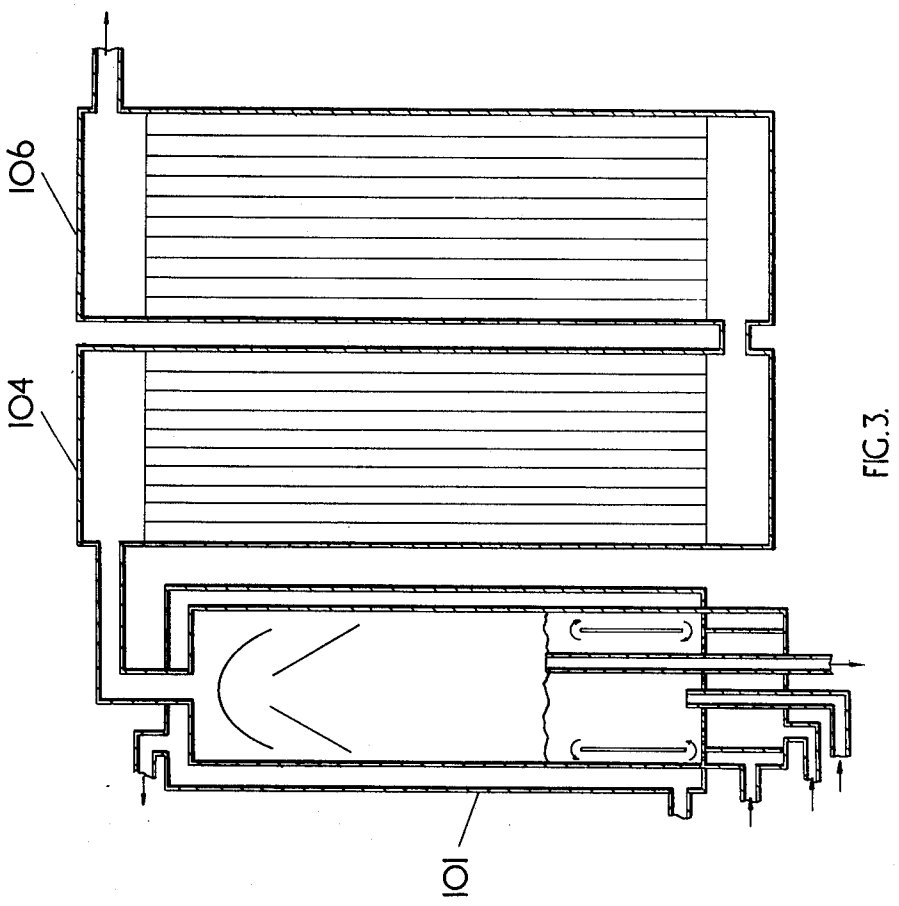


FIG.3.

FLUIDISED BED COMBUSTION

This invention has reference to a method and apparatus for the fluidised bed combustion of combustible matter.

The combustion of such matter in a fluidised bed of particulate matter is well known and its application to power generating systems has been the subject of investigation for many years. The heat transfer co-efficients attainable by employing the fluidised combustion technique represent a distinct improvement over conventional heat transfer modes such for example as a water tube boiler. However, one of the major difficulties attendant upon the utilisation of the technique in steam raising systems is that of variation of heat output of the bed to meet varying load demands. The variation of heat output is a particular problem as the bed temperature must be maintained at a level at which combustion is efficient. Additionally, with solid fuel there is always the danger of agglomeration and clinkering should the temperature of the bed be allowed to exceed a certain value. Thus it is necessary to have a method of varying the heat removal rate from the bed which allows the temperature of the bed to be maintained between certain temperature limits.

There have been a number of proposals for effecting such heat output variation but each has involved either expensive equipment to vary the amount of bed material and hence the amount of heat transfer surface in the bed or the danger of clinkering resulting from a section of the bed being allowed to slump i.e. the bed becomes defluidized whilst combustion is taking place.

According to a first aspect of the invention there is provided a method for the fluidised combustion of combustible matter including arranging a first fluidised bed of particulate material for heat transfer to a heat transfer medium adjacent a second fluidised bed of particulate material for the combustion of combustible matter, introducing said matter into the second bed and burning the matter therein, and circulating heat conductive material between the first and second beds.

Conveniently the first bed is arranged circumjacent the second bed.

Alternatively the first and second beds may be arranged side by side in mutual adjacency.

It is preferred that substantially all the combustion takes place within the second bed although it is to be appreciated that, in use, some unburnt combustible matter may be carried over into the first bed and burnt therein depending on the conditions prevailing therein.

The circulation of heat conductive material may conveniently be effected by the natural circulating movement of bed material from the centre of the bed to the boundaries thereof. However the rate of circulation of heat conductive material may be increased substantially over that by natural circulation by operating the first and second beds at different fluidising velocities i.e. the velocities at which fluidising medium e.g. air passes upwardly through the beds to fluidise them. Hence the material circulation rate may be controlled by variation of the two fluidising velocities or rates of fluidisation, thus the amount of heat transferred from the second, combustion bed to the first, heat transfer bed may be controlled. The fluidising velocity of the second, combustion bed will normally be higher than that of the first, heat transfer bed but may be equal to it.

According to a second aspect of the invention there is provided apparatus for the fluidised bed combustion of combustible matter including a combustor body adapted to contain particulate material, a gas-permeable support plate in the lower portion of the combustor body for supporting the material, a first, heat transfer region located adjacent a second, combustion region in said lower portion, a first fluidising medium inlet for the first region, and a second fluidising medium inlet for the second region.

Conveniently dividing means are provided in the lower portion to define the first and second regions, the dividing means being adapted to permit the circulation, in use, of material between the first and second regions. The dividing means may be so placed as to allow flow of material over and under it to give the said circulation between the regions. Alternatively the dividing means may be suitably apertured to allow such flow there through.

In an alternative form of the invention the dividing means may be omitted.

A fluidising medium plenum chamber is located subjacent the gas-permeable support plate and is divided into first and second zones corresponding to the first and second regions respectively in the lower portion of the combustor body, the first fluidising medium inlet being connected to the first zone and the second fluidising medium inlet being connected to the second zone.

Inlet means for combustible matter, e.g. fuel, is provided for the second, combustion region. Heat exchange means are provided in association with the first region. Such means may be incorporated in the wall of the combustor body, which defines a boundary of the first region. Alternatively or in addition the heat exchange means may be located within the region such that, in use, their heat exchange surfaces are immersed within the particulate material within the first region.

An exhaust outlet is provided in the combustor body and material separators may conveniently be arranged within the body intermediate the lower portion and the exhaust outlet.

According to a third aspect the invention provides a boiler system including an apparatus according to the second aspect of the invention.

Preferably two or more of such apparatus are included in the boiler system, the second, combustion region of each apparatus being connected to the second, combustion region of an adjacent apparatus.

Conveniently the exhaust outlet of each apparatus is connected to a heat exchange such that, in use, the hot gaseous products of combustion can be employed for heat exchange with an appropriate fluid.

By way of example only, a method and apparatus for the fluidised combustion of combustible matter according to the invention are described below with reference to the accompanying drawings in which:

FIG. **1** is a side elevation of a single apparatus;

FIG. **2** is a plan view of a boiler system incorporating the apparatus of FIG. **1**; and

FIG. **3** is a side elevation of the system shown in FIG. **2**.

Referring to FIG. **1**, apparatus for the fluidised combustion of combustible matter includes a combustor body **1** of circular cross-section having towards its lower end a perforate support grid **2** adapted to support particulate material. The body **1** is provided with a ple-

num chamber **4**, located below the grid **2**, and this serves to distribute air or other fluidising medium through the grid **2**. The chamber **4** has two inlets **6, 8** each adapted for introducing a fluidising medium into the plenum chamber **4** which is divided into a first, outer zone or section **10**, and a second, inner zone or section **12**. The inlets **6, 8** serve the sections **10, 12** respectively.

The lower portion **14** of the body **1** is adapted to contain and support particulate material **16** and is divided into two regions by a cylinder **18**, the first outer region **20** being of annular form and the second inner region **22** being of cylindrical form. The cylinder **18** is so disposed within portion **14** that material transfer between the first and second regions **20, 22** can, in use, be effected. The lower end of the cylinder **18** is spaced from the support grid **2** to allow of material flow from one region to its adjacent region. Similarly material flow can take place, in use, over the upper end of the cylinder **18**.

The second inner region **22**, in use, contains a second bed of material in which combustion of fuel is to take place and accordingly a fuel inlet **24** is provided for this region **22**.

The first outer region **20**, in use, contains a first bed of material from which heat is to be transferred to a fluid medium and to this end the combustor body **1** is provided with a heat exchange jacket **26** having a suitable inlet **28** and outlet **30**.

The combustor body **1** has an exhaust gas outlet **31** and separators **32** are located within the body **1** as shown for the purpose in use of arresting particulate material which may be carried up from the bed by the exhaust gases of combustion or fluidising medium. A weir **34** is provided for regulating the level of material **36** within the combustor.

The operation of the apparatus is as follows:

Finely divided particulate material, e.g. inert material such as ash residue from the combustion of coal, is placed within the body **1** to the requisite level in the lower portion **14** thereof and supported by grid **2**. A fluidising medium, e.g. air, is introduced through the inlet **8** to fluidise the material **16** in region **22**. The fluidising medium may be preheated to heat the material **16** for initial start-up to raise its temperature to that at which the combustion of fuel, in this case coal, will be self-sustaining. Coal is introduced via inlet **24** only into the region **22** for combustion in a fluidised state therewithin. When the bed material is at a sufficiently high temperature a fluidising medium is introduced into the outer region **20**. The fluidising velocity of the fluidising medium entering the region **22** is arranged to be higher than that entering the region **20** thus resulting in material circulation between region **22** to region **20**. The hot material passes over the top of the cylinder **18** and passes from the second bed in region **22** to the first bed in region **20**, material also passing below cylinder **18** from region **20** to region **22** thus providing an overall circulation of material within the combustor body; heat transfer is thus effected between the material and the heat transfer medium e.g. water in the jacket **26**. In order to reduce the heat output of the apparatus the rate of circulation of bed material between the regions **20, 22** is reduced as the fuel feed is reduced. Because of the reduction in the material circulation rate the temperature of the second bed can be maintained constant despite the lowering of the fuel feed. The reduction in the material circulation rate between the first and second beds is effected by varying the fluidising velocities in the two regions **20, 22**. Thus as the fuel feed is reduced, the flow of air to region **22** can be reduced to maintain the desired level of excess air for combustion requirements. At the same time the flow of air to region **20** may also be varied if necessary to reduce the difference between the two fluidising velocities and so reduce the material circulation rate. Since the amount of transfer of heat from the second bed in region **22** to the first bed in region **20** and thence to the heat transfer fluid in jacket **26** can be controlled as described above, the temperature in the combustion bed can be controlled within required temperature limits. Thus the problems associated with low load operation of fluidised bed heat exchangers hitherto proposed are obviated.

In order to increase the heat output of the apparatus the fuel feed rate is increased together with the flow rate of air to region **22** and the material circulation is thus increased to maintain the temperature in the second, combustion region within the required limits. This could conveniently be controlled by the automatic variation of the air flow rates to regions **20, 22**.

Referring now to FIGS. **2** and **3**, a boiler system is illustrated and comprises three units of apparatus as described with reference to FIG. **1** designated **101, 102** and **103**. The constructional features of the units are the same as those of FIG. **1** and no further description thereof is included with reference to FIGS. **2** and **3**. The second region **22** of unit **101** is connected to the second region of unit **102** by a conduit **105** and that of unit **102** is connected to the second region of **103** by a conduit **107**. The exhaust gas outlet of each unit is connected to heat exchangers **104, 106** arranged in series as shown in FIGS. **2** and **3**, the outlets of each exchanger **106** being connected to a common exhaust manifold **108**.

The unit **101** is the main unit of the three and is provided with controls (not shown) including an on-off control for a fluidising air fan (not shown), a damper to vary the flow rate to region **20**, and a control for the fuel feed rate. Each of units **102, 103** is provided with similar controls to those for unit **101** but their fuel feeders may be interconnected.

The operation of the boiler system is as follows:

The material within the region **22** of unit **101** is fluidised and heated to a temperature sufficient for self-sustaining combustion of the fuel feed. Fuel is introduced into the bed for combustion therein and is controlled according to the heat output required of the region **20**, material transfer between the regions **20, 22** additionally being varied according to the demand.

When the maximum heat output of unit **101** is attained, unit **102** is brought into operation. This is effected by fluidising material in region **22** thereof and by introducing hot material from the region **22** of unit **101** through conduit **105** into the region **22** of unit **102**. This introduction of hot material heats the bed in unit **102** to a suitable temperature and thereafter fuel feed is commenced. Thus additional heat output of the system is achieved by bringing unit **102** into operation and the individual heat output of this unit and thus the combustion temperature of the second bed thereof can be controlled by material transfer between the first and second regions of that unit **102**. If additional heat output is required, unit **103** can be brought into operation

in similar manner as unit **102** with initial heating of the second bed region **22** thereof being effected by hot material being transferred along conduit **107.**

As the heat demand is reduced the units **103, 102** can be gradually shut-down one by one by stopping fuel feed and, after combustion is complete by stopping material transfer between the first and second beds.

It is to be appreciated that any number of units similar to units **102, 103** may be utilised for the same purposes i.e. increasing heat output of the system, each unit having similar heat exchangers **104** and **106.**

It is to be understood that whilst a circular section combustor has been described, a combustor body of rectangular or any other section falls within the scope of the invention. In the case of a rectangular section combustor body the first region need not completely surround the second region but only partially, for example adjacent two opposite side walls of the combustor body. However, the first region may completely surround the second region in a combustor body of rectangular section.

The principle of operation described in relation to FIGS. **2** and **3** could be applied to a boiler system in which the apparatus **101, 102** and **103** comprise adjacent rectangular bodies housed in a single casing with intervening baffles separating the beds of each apparatus.

In alternative embodiments the first heat transfer region may be sub-divided into two or more sections each having a separate plenum chamber for the fluidising medium. This would facilitate control of the combustion temperature particularly during operation for long periods at low heat output.

Additionally in further alternative embodiments the cylinder **18** of the apparatus of FIG. **1** or corresponding dividing means may be omitted.

I claim:

1. A method for the fluidised combustion of combustible matter including the steps of arranging a first, heat transfer bed of particular material adjacent a second, combustion bed of particular material, introducing a fluidising medium into the first and second beds, introducing combustible matter into the second bed, burning the matter in the second bed, circulating heat conductive material between the first and second beds, passing a heat transfer medium in association with the first bed, and varying the rate of heat transfer in the first bed to the heat transfer medium by varying the rate of circulation of the heat conductive material between the first and second beds.

2. Fluidised combustion apparatus including a combustor body, a lower portion in the combustor body, a particulate material gas-permeable support plate in the lower portion, a first, heat transfer region in the lower portion above the plate, heat exchange means associated with the first, heat transfer region, a second, combustion region in the lower portion located adjacent the first region, a first fluidising medium inlet means located below the plate and adapted to introduce a fluidising medium to the first region, and a second fluidising medium inlet means located below the plate and adapted to introduce a fluidising medium to the second region.

3. A method according to claim **1** in which the rate of circulation of heat conductive material between the first and second beds is varied by varying velocities of the fluidising medium to each of the first and second beds.

4. A method according to claim **3** in which the velocity of the fluidising medium in the second bed is equal to the velocity of the fluidising medium in the first bed.

5. A method according to claim **3** in which the velocity of the fluidising medium in the second bed is greater than the velocity of the fluidising medium in the first bed.

6. A method according to claim **1** in which substantially all the combustion of the combustible matter takes place within the second bed.

7. A method according to claim **1** in which the first bed is arranged circumjacent the second bed.

8. A method according to claim **1** in which the first and second beds are arranged side-by-side in mutual adjacency.

9. Apparatus according to claim **2** in which dividing means are provided in the lower portion of the combustor body to define the first and second regions.

10. Apparatus according to claim **9** in which the dividing means are adapted to permit circulation of material between the first and second region,

11. Apparatus according to claim **10** in which the dividing means are spaced from the gas-permeable support plate.

12. Apparatus according to claim **2** in which a fluidising medium plenum chamber is located subjacent the gas-permeable support plate, a first zone is defined within the chamber and is connected to the first fluidising medium inlet, and a second zone is defined adjacent the first zone and is connected to the second fluidising medium inlet.

13. Apparatus according to claim **2** in which inlet means for combustible material are provided for the second, combustion region.

14. Apparatus according to claim **2** in which the heat exchange means is incorporated in the combustor body wall.

15. Apparatus according to claim **2** in which an exhaust outlet means is provided in the combustor body, and material separators are arranged within the body intermediate the lower portion and the exhaust outlet means.

16. A boiler system including an apparatus according to claim **2.**

17. A boiler system according to claim **16** in which the system includes more than one apparatus, and the second region of the combustor body of one apparatus is connected to the second region of an adjacent apparatus.

18. A boiler system according to claim **17** in which the combustor body of each apparatus has an exhaust outlet means and a heat exchanger is connected to the exhaust outlet means.

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