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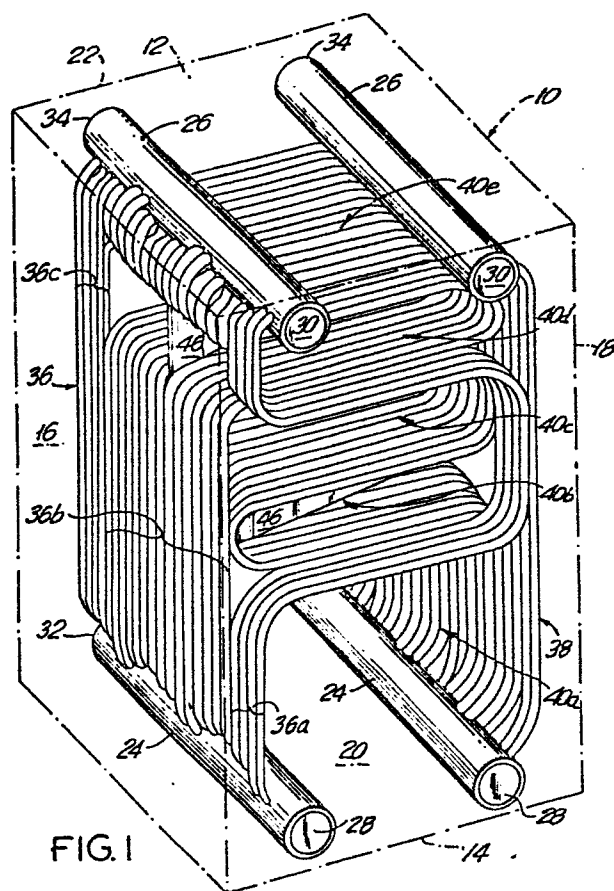
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**Water tube boiler.**

In a water tube boiler comprising a housing (20) enclosing tubes (36,38) bent to form vertical chambers (40a-40e) successively traversed by rising hot combustion gases, the tubes being connected at the bottom to a cold water manifold (24) and at the top to a steam manifold (26), the manifolds project beyond the housing with a downcomer outside the housing connecting the top of the lower manifold and the lowest part of the upper manifold, thereby permitting the boiler to operate with a shallow level of water in the upper manifold, speeding up circulation of water and its heating, and permitting substantially dry steam to be discharged from the upper manifold. The chambers may include baffles (46) which are angled so that the hot gas hits them at an angle less than 90° so as to be deflected thereby in the direction of its advance, thereby avoiding hot spots. Advantageously successive chambers from bottom to top are reduced in volume to make up for the reduction in volume as the hot gas cools, thereby keeping the gas velocity high and maintaining turbulence which helps heat exchange. For efficient fuel utilization, notwithstanding fluctuations in demand, the operator can monitor the oxygen content of the exiting combustion gas and adjust the baffling to maintain it substantially constant.



This application relates to improvements in the construction and operation of a water tube boiler comprising a housing containing upper and lower left and right water manifolds. Tubes connect the left manifolds and other tubes the right manifolds. The tubes are bent toward one another to form a plurality of superposed chambers through which combustion gases must successively flow, from front to back in one chamber and from back to front within the next.

In U.S. Patent 4,355,602 there is described a simple boiler of the abovementioned type which is relatively simple and inexpensive to manufacture and operate. That boiler comprises a housing having a top provided with a gas outlet, bottom, left and right sides and a front and back, the housing containing an upper manifold and a lower manifold substantially parallel to the top, bottom and side walls, two sets of tubes, each set comprising a plurality of tubes, one set joining the upper manifold to the lower manifold on the left and the other set joining the upper manifold to the lower manifold on the right, the tubes of each set rising from the lower manifold upwardly along their respective side wall, crossing the housing to the opposite side wall, rising adjacent the opposite side wall, re-crossing the housing to their respective side wall, rising therealong and eventually joining the upper manifold, the horizontal runs of the tubes of one set being vertically offset relative to the horizontal runs of the tubes of the other set so as to form a plurality of superposed chambers, individual tubes of the sets being differently bent so as to form access openings from each chamber to the chambers above and below, the openings from chamber to chamber being

offset so as to require a gas flowing through said chambers to traverse one chamber from front to back and the next chamber from back to front, means for introducing liquid into one of the manifolds and for withdrawing the liquid from the other manifold, and means for introducing a hot gas into the lowermost of the superposed chambers, the hot gas rising successively through the chambers which it successively and alternately traverses from front to back and then from back to front until it exits from the uppermost chamber through the gas outlet in the top, liquid flowing through the manifolds and tubes being heated by the hot gas, at least one baffle within at least one of the chambers extending from top to bottom and from one of the sides toward but terminating short of the other, whereby hot gas traversing that chamber from front to back is additionally forced to flow laterally to get around said baffle.

It is an object of the present invention to improve the efficiency of operation of such a boiler by simple structural modifications and by simple procedural demands.

These and other objects and advantages are realized in accordance with the present invention pursuant to which at least one upper and at least one lower manifold project from the inside of the housing to the outside. A downcomer outside the housing connects the top of the lower manifold and the lowest part of the upper manifold, thereby permitting the boiler to operate within a shallow level of water in the upper manifold, speeding up circulation of water and its heating, and permitting substantially dry steam to be discharged from the upper manifold.

In accordance with another aspect of the invention the baffle (or baffles) is angled within its chamber so that the hot gas hits it at an angle less than  $90^\circ$  so as to be deflected thereby in the direction of its advance, thereby avoiding hot spots.

In accordance with yet another aspect of the invention successive chambers of the boiler are reduced in volume from bottom to top to make up for the reduction in volume as the hot gas cools, thereby keeping the gas velocity high and maintaining turbulence which helps heat exchange.

Finally, to maintain efficient fuel utilization while fluctuating the feed of fuel, the operator can monitor the oxygen content of the exiting combustion gas and adjust the baffling to maintain it substantially constant.

The invention will be further described with reference to the accompanying drawings, wherein:

Fig. 1 is a perspective view of a boiler in accordance with the invention;

Fig. 2 is a front view of the boiler of Fig. 1 without baffles and downcomer;

Fig. 3 is a side view of the boiler showing the connection of tubes and downcomer with the manifolds;

Fig. 4 is a plan view of the preferred arrangement of baffles in a chamber of the boiler; and

Fig. 5 is a perspective view of one baffle of Fig. 4.

Referring now more particularly to the drawings, in Fig. 1 there is shown a housing 10 having a top wall 12, a bottom wall 14, a left side wall 16, a right side wall 18, a front wall 20 and a rear wall 22. A lower manifold 24 and an upper manifold 26 project through the front and rear walls 20 and 22. Means are provided to introduce cold water into the lower manifold at 28 and to remove steam from the upper manifold at 30, outside the housing.

A downcomer 32 outside the housing connects the lowest part of the upper manifold 26 with the top of the lower manifold 24 so that water in the upper manifold can rapidly run down for reheating, speeding up the circulation. This also permits the upper manifold to operate with a shallow level of water which also speeds up production of steam and which permits substantially dry steam to be discharged from the upper manifold 26.

A plurality of tubes 36, illustratively twenty-three, extend from the left upper manifold 26 to the left lower manifold 24 and a similar number of tubes 38 extend from the right upper manifold 26 to the right lower manifold 24. Except for the first 36a and last 36c few tubes in each set, for a reason to be described later, the balance of the tubes 36b are all similarly bent as are the tubes 38.

Each tube has a vertical component and tubes 38a and 38b have two horizontal components, i.e. one run to the left side of the boiler, or actually to the tubes 36, and then a return run. The bends in tubes 38 are not identical to those of tubes 36 but rather complementary so that together they form a series of vertically superposed chambers 40a, 40b, 40c, 40d and 40e, decreasing in volume from bottom to top to make up

for reduction in volume as the hot gas cools, thereby keeping the gas velocity high and maintaining turbulence which helps heat exchange.

Advantageously, the boiler has five, seven or nine chambers. Combustion gases in chamber 40a rise through such space and enter chamber 40b traversing it horizontally from back to front. The tube bends similarly cause the gases to traverse successive chambers until they reach the topmost chamber 40e where they exit through an opening in the top 12.

For improved heat exchange, in addition to the tortuous gas flow so far defined, a more complex flow is possible. Thus rectangular baffles 46 having the shape shown in Fig. 5 may be provided, extending from adjacent one side wall toward but short of the other. They are just high enough to span a chamber being held in position by their fit between the troughs formed by adjacent tubes. They are inserted by simple sliding and may be removed, or slid more or less into their chambers, either manually or automatically (not shown), as desired.

If more than one baffle 46 is present in a given chamber they must alternately extend from opposite sides. Thus while the combustion gas is moving from rear to front in chamber 40b the gas stream must move from side to side to get around the baffles.

As shown in Figs. 4 and 5 the baffles have front and rear elements which are high and low enough to lodge in the nips between adjacent tubes. In between there is a lower section which is just high enough to clear the minimum vertical space of the chamber. This section is arranged at an angle less than  $90^\circ$ , e.g. about  $45^\circ$  so the gas will be deflected

off it in a direction which will help advance the gas, thereby avoiding hot spots.

In Figs. 1 and 3 it can be seen that the connections between the tubes and upper manifold are not in a straight line but rather are staggered. However, all the tubes join the upper manifold at or below the upper manifold's horizontal center line and each tube in going from lower to upper manifold has lengths which rise or are horizontal but has no lengths which go downwardly, thereby avoiding entrapment of gas.

The baffles can serve a further purpose, viz. maintaining efficient utilization of fuel notwithstanding fluctuating fuel feed rates as a consequence of fluctuation in steam demand. Specifically, one monitors the oxygen content of the hot gas exiting the boiler which otherwise will change as feed and demand vary. However, the position of the baffle or baffles is adjusted to maintain this oxygen content substantially constant, e.g. as demand goes down the oxygen content will go up, so the baffle positions will be adjusted to give more baffling and thereby restore the oxygen level to the predetermined value.

It will be understood that the specification and examples are illustrative but not limitative of the present invention and that other embodiments within the spirit and scope of the invention will suggest themselves to those skilled in the art.

WHAT IS CLAIMED:

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1. In a boiler comprising a housing having a top provided with a gas outlet, bottom, left and right sides and a front and back, the housing containing an upper manifold and a lower manifold substantially parallel to the top, bottom and side walls, two sets of tubes, each set comprising a plurality of tubes, one set joining the upper manifold to the lower manifold on the left and the other set joining the upper manifold to the lower manifold on the right, the tubes of each set rising from the lower manifold upwardly along their respective side wall, crossing the housing to the opposite side wall, rising adjacent the opposite side wall, re-crossing the housing to their respective side wall, rising therealong and eventually joining the upper manifold, the horizontal runs of the tubes of one set being vertically offset relative to the horizontal runs of the tubes of the other set so as to form a plurality of superposed chambers, individual tubes of the sets being differently bent so as to form access openings from each chamber to the chambers above and below, the openings from chamber to chamber being offset so as to require a gas flowing through said chambers to traverse one chamber from front to back and the next chamber from back to front, means for introducing liquid into one of the manifolds and for withdrawing the liquid from the other manifold, and means for introducing a hot gas into the lowermost of the superposed chambers, the hot gas rising successively through the chambers which it successively and alternately traverses from front to back and then from back to front until it exits from the uppermost chamber through the gas outlet in the top, liquid flowing through the manifolds and tubes being heated by the hot gas, at least one baffle within at least one of the chambers extending from top to bottom and from one

of the sides toward but terminating short of the other, whereby hot gas traversing that chamber from front to back is additionally forced to flow laterally to get around said baffle, the improvement which comprises having at least one upper and at least one lower manifold project from the inside of the housing to the outside, and a downcomer outside the housing connecting the top of the lower manifold and the lowest part of the upper manifold, thereby permitting the boiler to operate with a shallow level of water in the upper manifold, speeding up circulation of water and its heating, and permitting substantially dry steam to be discharged from the upper manifold.

2. A boiler according to claim 1, wherein all the tubes join the upper manifold at or below the upper manifold's horizontal center line.

3. A boiler according to claim 2, wherein each tube in going from lower to upper manifold has lengths which rise or are horizontal but has no lengths which go downwardly, thereby avoiding entrapment of gas.

4. A boiler according to claim 1, wherein the boiler has five, seven or nine chambers.

5. A boiler according to claim 1, wherein the baffle is angled within its chamber so that the hot gas hits it at an angle less than  $90^\circ$  so as to be deflected thereby in the direction of its advance, thereby avoiding hot spots.

6. A boiler according to claim 1, wherein successive chambers from bottom to top are reduced in volume to make up for the reduction in volume as the

hot gas cools, thereby keeping the gas velocity high and maintaining turbulence which helps heat exchange.

7. A boiler according to claim 6, including a plurality of baffles in a plurality of chambers, the baffles being angled within their chambers so that the hot gas hits them at an angle less than  $90^\circ$  so as to be deflected thereby in the direction of its advance, thereby avoiding hot spots.

8. In a boiler comprising a housing having a top provided with a gas outlet, bottom, left and right sides and a front and back, the housing containing an upper manifold and a lower manifold substantially parallel to the top, bottom and side walls, two sets of tubes, each set comprising a plurality of tubes, one set joining the upper manifold to the lower manifold on the left and the other set joining the upper manifold to the lower manifold on the right, the tubes of each set rising from the lower manifold upwardly along their respective side wall, crossing the housing to the opposite side wall, rising adjacent the opposite side wall, re-crossing the housing to their respective side wall, rising therealong and eventually joining the upper manifold, the horizontal runs of the tubes of one set being vertically offset relative to the horizontal runs of the tubes of the other set so as to form a plurality of superposed chambers, individual tubes of the sets being differently bent so as to form access openings from each chamber to the chambers above and below, the openings from chamber to chamber being offset so as to require a gas flowing through said chambers to traverse one chamber from front to back and the next chamber from back to front, means for introducing liquid into one of the manifolds and for withdrawing the liquid from the other manifold, and means for introducing a hot gas into the lowermost of

the superposed chambers, the hot gas rising successively through the chambers which it successively and alternately traverses from front to back and then from back to front until it exits from the uppermost chamber through the gas outlet in the top, liquid flowing through the manifolds and tubes being heated by the hot gas, at least one baffle within at least one of the chambers extending from top to bottom and from one of the sides toward but terminating short of the other, whereby hot gas traversing that chamber from front to back is additionally forced to flow laterally to get around said baffle, the improvement which comprises angling the baffle within its chamber so that the hot gas hits it at an angle less than  $90^\circ$  so as to be deflected thereby in the direction of its advance, thereby avoiding hot spots.

9. A boiler according to claim 7, wherein successive chambers from bottom to top are reduced in volume to make up for the reduction in volume as the hot gas cools, thereby keeping the gas velocity high and maintaining turbulence which helps heat exchange.

10. A boiler according to claim 9, including a plurality of baffles in a plurality of chambers, the baffles being angled within their chambers so that the hot gas hits them at an angle less than  $90^\circ$  so as to be deflected thereby in the direction of its advance, thereby avoiding hot spots.

11. In a boiler comprising a housing having a top provided with a gas outlet, bottom, left and right sides and a front and back, the housing containing an upper manifold and a lower manifold substantially parallel to the top, bottom and side walls, two sets of tubes, each set comprising a plurality of tubes, one set joining the upper manifold to the lower manifold on

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the left and the other set joining the upper manifold to the lower manifold on the right, the tubes of each set rising from the lower manifold upwardly along their respective side wall, crossing the housing to the opposite side wall, rising adjacent the opposite side wall, re-crossing the housing to their respective side wall, rising therealong and eventually joining the upper manifold, the horizontal runs of the tubes of one set being vertically offset relative to the horizontal runs of the tubes of the other set so as to form a plurality of superposed chambers, individual tubes of the sets being differently bent so as to form access openings from each chamber to the chambers above and below, the openings from chamber to chamber being offset so as to require a gas flowing through said chambers to traverse one chamber from front to back and the next chamber from back to front, means for introducing liquid into one of the manifolds and for withdrawing the liquid from the other manifold, and means for introducing a hot gas into the lowermost of the superposed chambers, the hot gas rising successively through the chambers which it successively and alternately traverses from front to back and then from back to front until it exits from the uppermost chamber through the gas outlet in the top, liquid flowing through the manifolds and tubes being heated by the hot gas, at least one baffle within at least one of the chambers extending from top to bottom and from one of the sides toward but terminating short of the other, whereby hot gas traversing that chamber from front to back is additionally forced to flow laterally to get around said baffle, the improvement wherein successive chambers from bottom to top are reduced in volume to make up for the reduction in volume as the hot gas cools, thereby keeping the gas velocity high and maintaining turbulence which helps heat exchange.

12. A process for maintaining efficient utilization of fuel while fluctuating the feed of fuel to a burner supplying hot combustion gas to the lowermost chamber of a boiler comprising a housing having a top provided with a gas outlet, bottom, left and right sides and a front and back, the housing containing an upper manifold and a lower manifold substantially parallel to the top, bottom and side walls, two sets of tubes, each set comprising a plurality of tubes, one set joining the upper manifold to the lower manifold on the left and the other set joining the upper manifold to the lower manifold on the right, the tubes of each set rising from the lower manifold upwardly along their respective side wall, crossing the housing to the opposite side wall, rising adjacent the opposite side wall, re-crossing the housing to their respective side wall, rising therealong and eventually joining the upper manifold, the horizontal runs of the tubes of one set being vertically offset relative to the horizontal runs of the tubes of the other set so as to form a plurality of superposed chambers, individual tubes of the sets being differently bent so as to form access openings from each chamber to the chambers above and below, the openings from chamber to chamber being offset so as to require a gas flowing through said chambers to traverse one chamber from front to back and the next chamber from back to front, means for introducing liquid into one of the manifolds and for withdrawing the liquid from the other manifold, and means for introducing a hot gas into the lowermost of the superposed chambers, the hot gas rising successively through the chambers which it successively and alternately traverses from front to back and then from back to front until it exits from the uppermost chamber through the gas outlet in the top, liquid flowing through the manifolds and tubes being heated by the hot gas, at least one baffle

within at least one of the chambers extending from top to bottom and from one of the sides toward but terminating short of the other, whereby hot gas traversing that chamber from front to back is additionally forced to flow laterally to get around said baffle, comprising monitoring the oxygen content of the hot gas exiting the boiler, and adjusting the position of the baffle substantially to restore the oxygen content to a predetermined value.

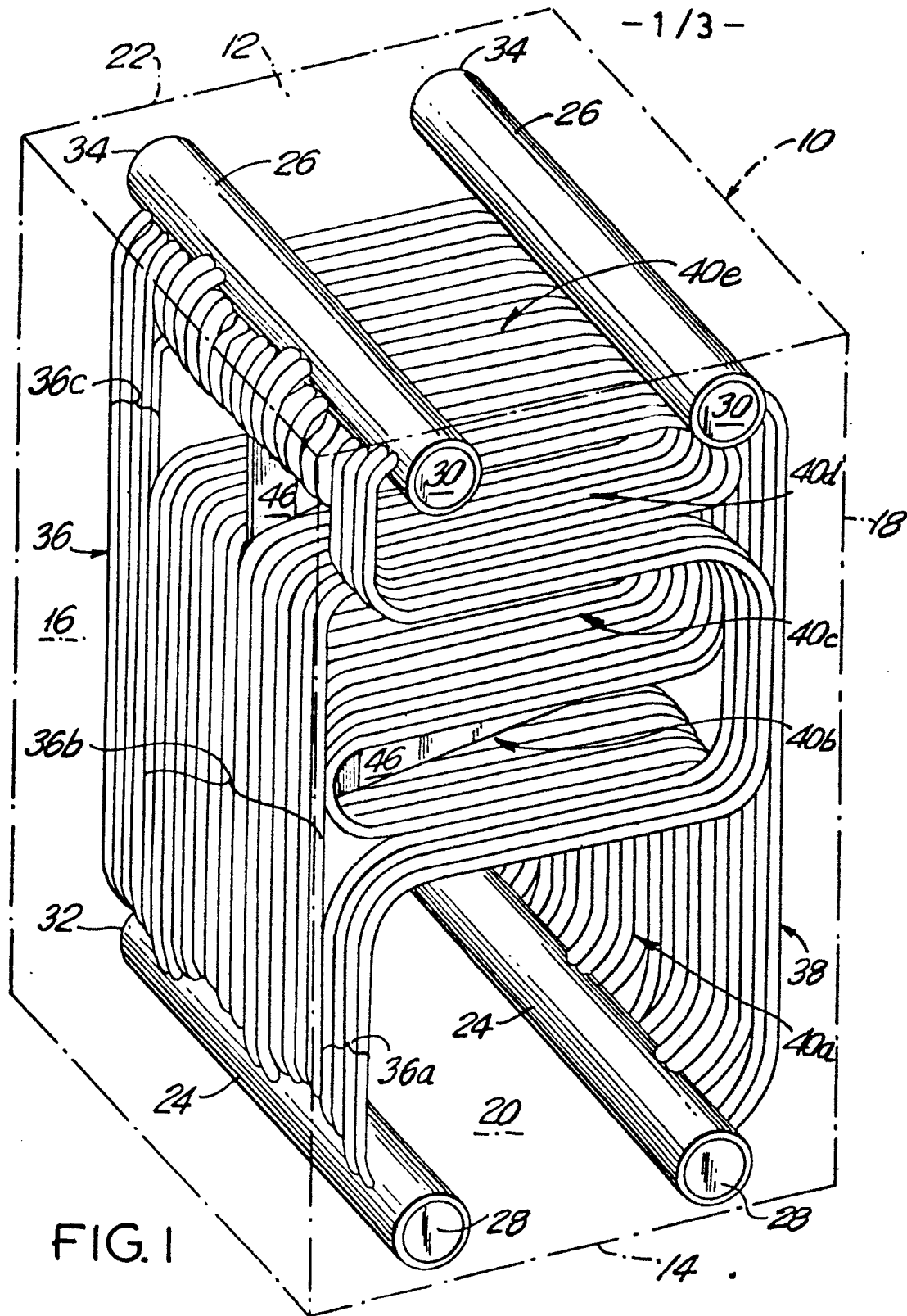


FIG. 1

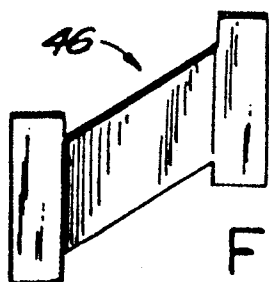


FIG. 5

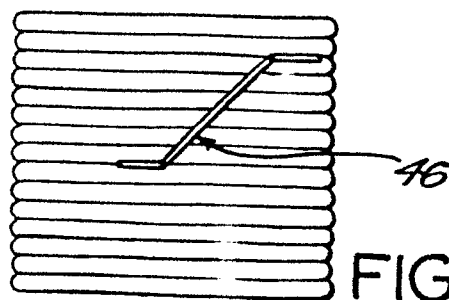


FIG. 4

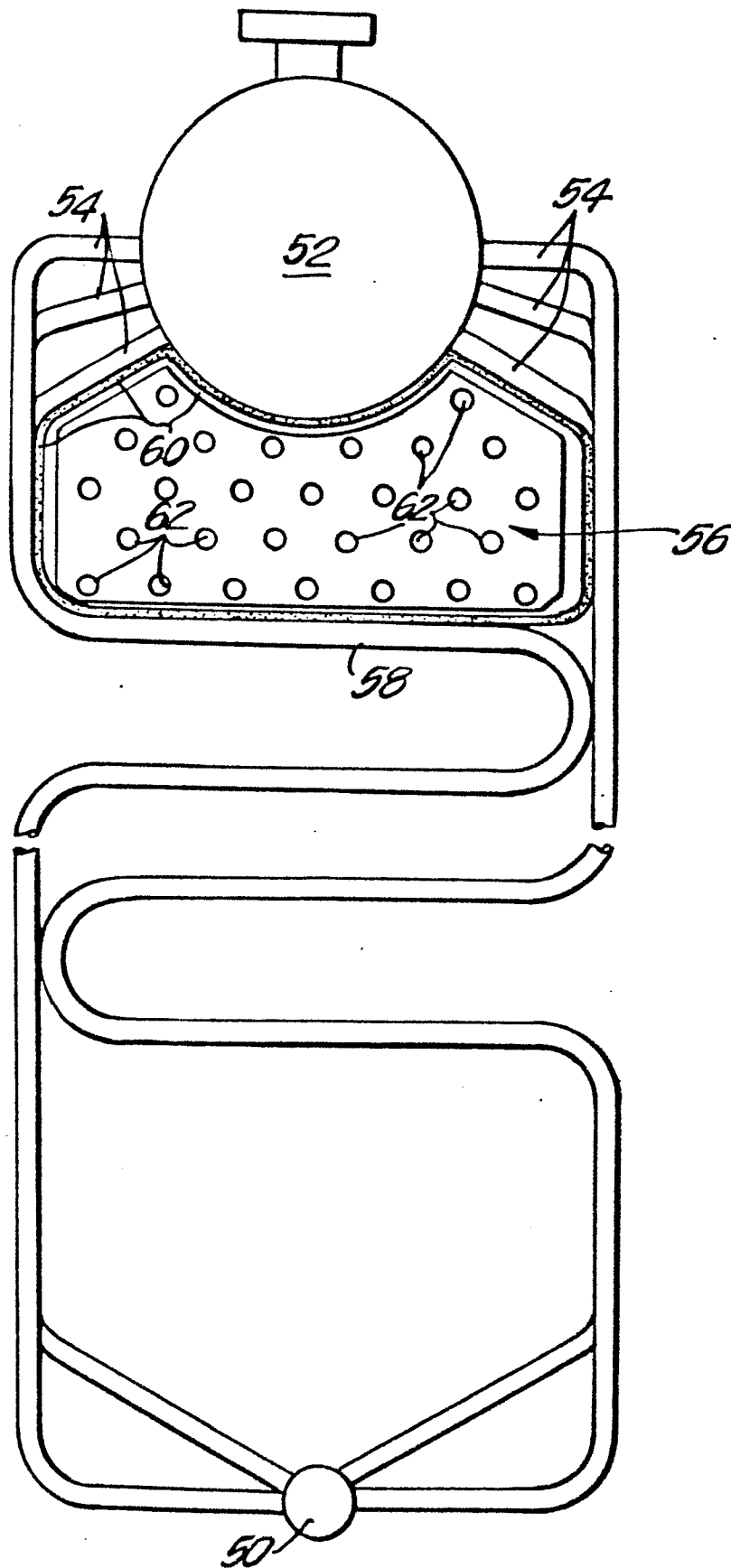


FIG. 2

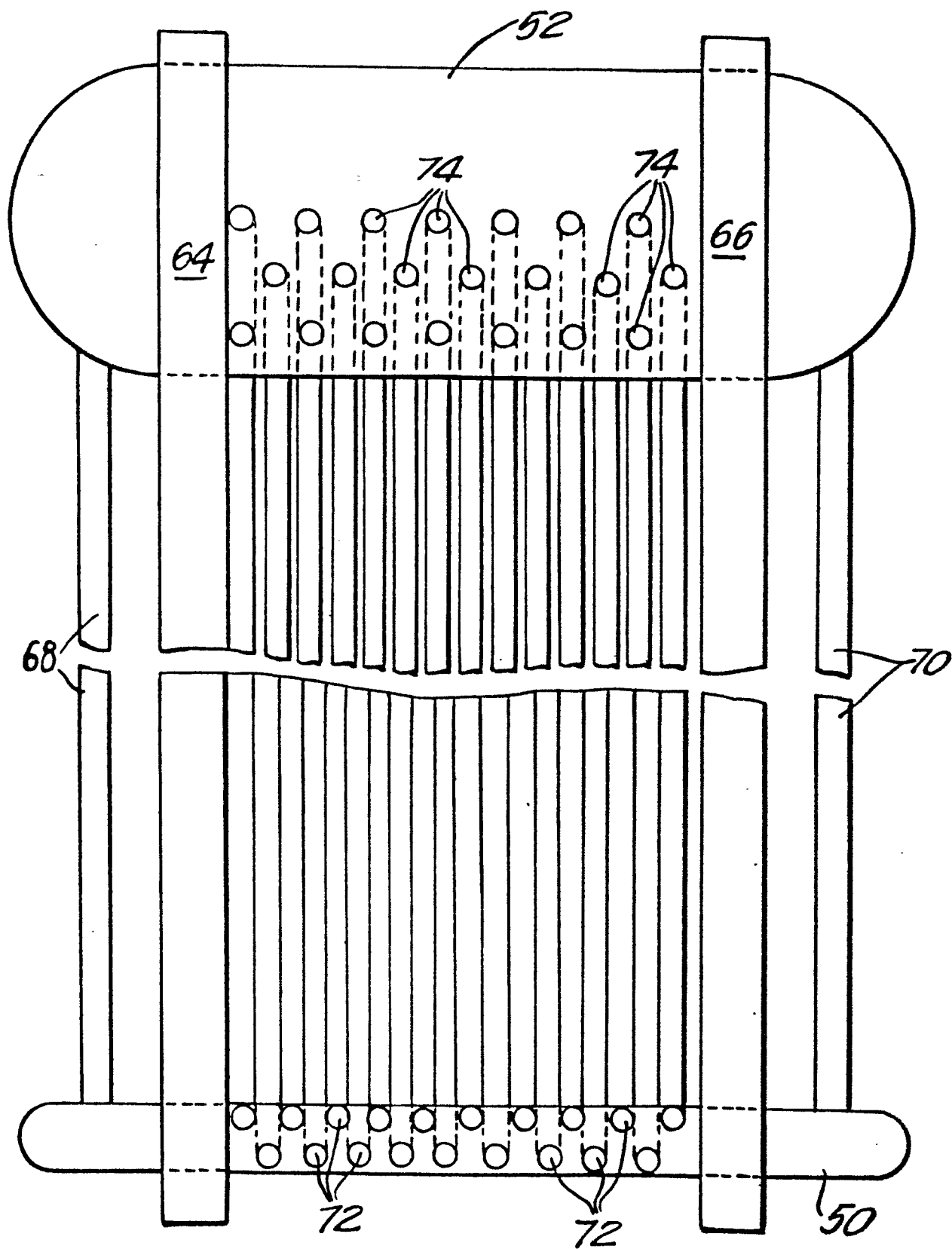


FIG. 3



European Patent  
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# EUROPEAN SEARCH REPORT

**0169256**

Application number

EP 84 10 8703

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                     |                                                |                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------|------------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Citation of document with indication, where appropriate, of relevant passages       | Relevant to claim                              | CLASSIFICATION OF THE APPLICATION (Int. Cl. 4) |
| D,Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US-A-4 355 602 (COOKE)<br>* Claim 1; figure 4; reference 46<br>*                    | 1                                              | F 24 H 1/40<br>F 22 B 21/22<br>F 22 B 37/40    |
| D,A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * Figure 1 *                                                                        | 5, 8, 11                                       |                                                |
| D,X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * Column 4, line 50 - column 5, line 7 *                                            | 12                                             |                                                |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | ---<br>US-A-1 990 743 (MC-GUINESS)<br>* Page 2, lines 12-30 *                       | 1                                              |                                                |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | * Figure 2; references 23, 46; page 2, lines 39-75 *                                | 2, 3                                           | TECHNICAL FIELDS<br>SEARCHED (Int. Cl. 4)      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | ---<br>AT-B- 93 517 (CLAYTON & SHUTTLEWORTH LTD. et al.)<br>* Page 1, lines 20-37 * | 5                                              | F 22 B 21/00<br>F 22 B 37/00<br>F 24 H 1/00    |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | ---<br>EP-A-0 052 939 (ENCON LTD.)                                                  |                                                |                                                |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | ---<br>WO-A-8 304 087 (JUHASZ)<br>-----                                             |                                                |                                                |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                     |                                                |                                                |
| Place of search<br>BERLIN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                     | Date of completion of the search<br>05-03-1985 | Examiner<br>PIEPER C                           |
| <p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>D : document cited in the application<br/>L : document cited for other reasons<br/>&amp; : member of the same patent family, corresponding document</p> |                                                                                     |                                                |                                                |