June 5, 1934.

K. A. MAYR

1,961,233

STEAM GENERATING APPARATUS

Filed July 3, 1929

10 Sheets-Sheet 1

FIG. 1.

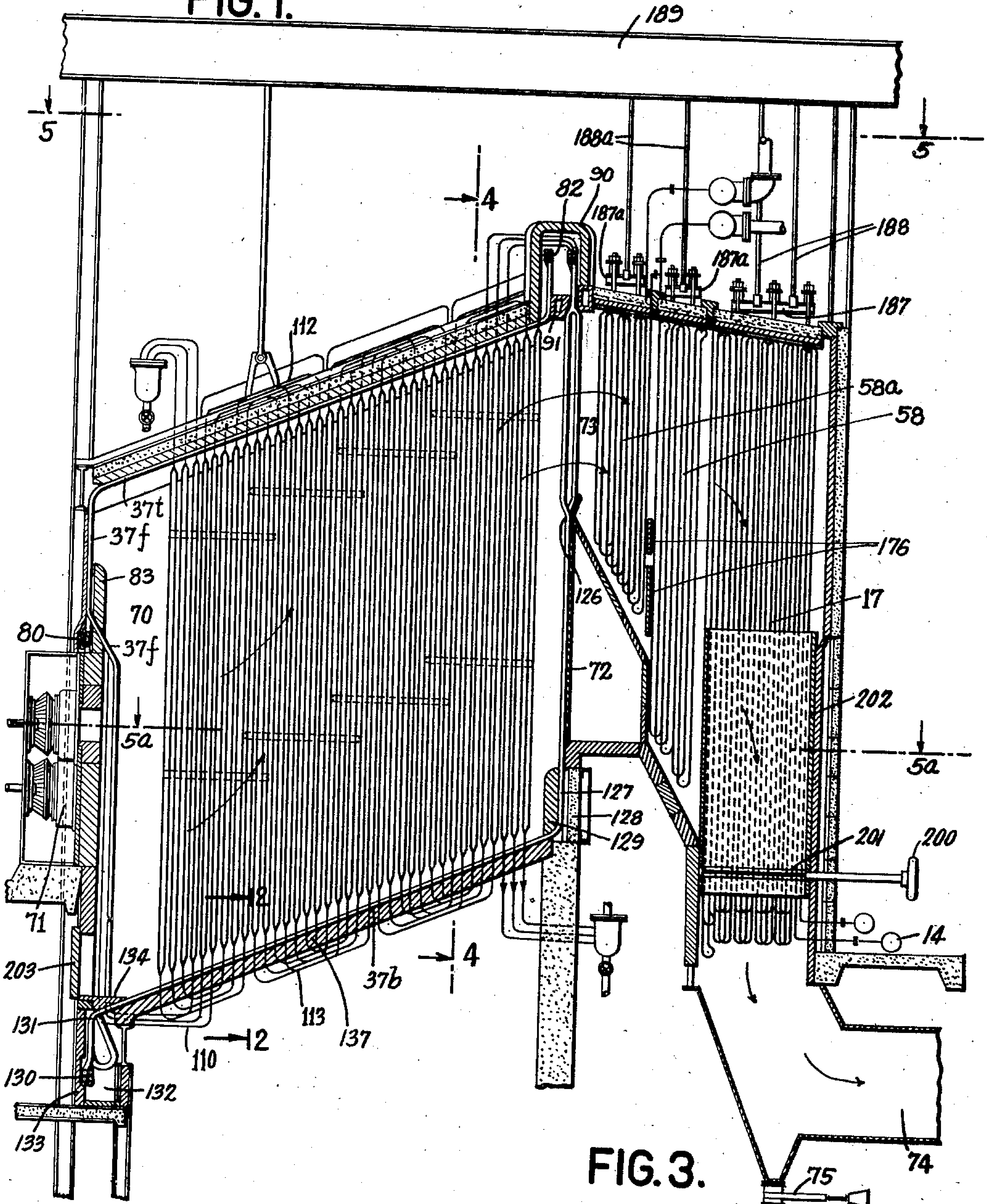

FIG. 3.

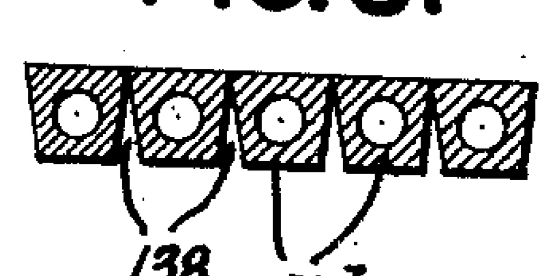

FIG. 2.

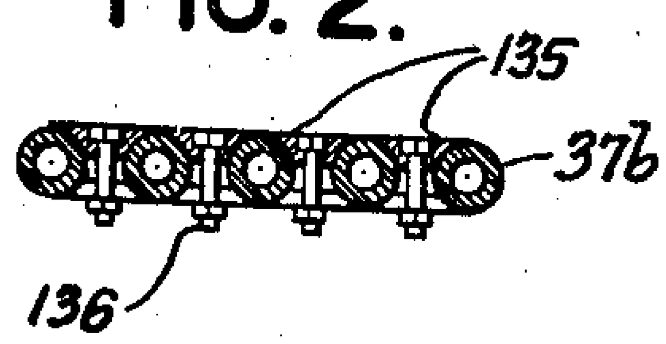

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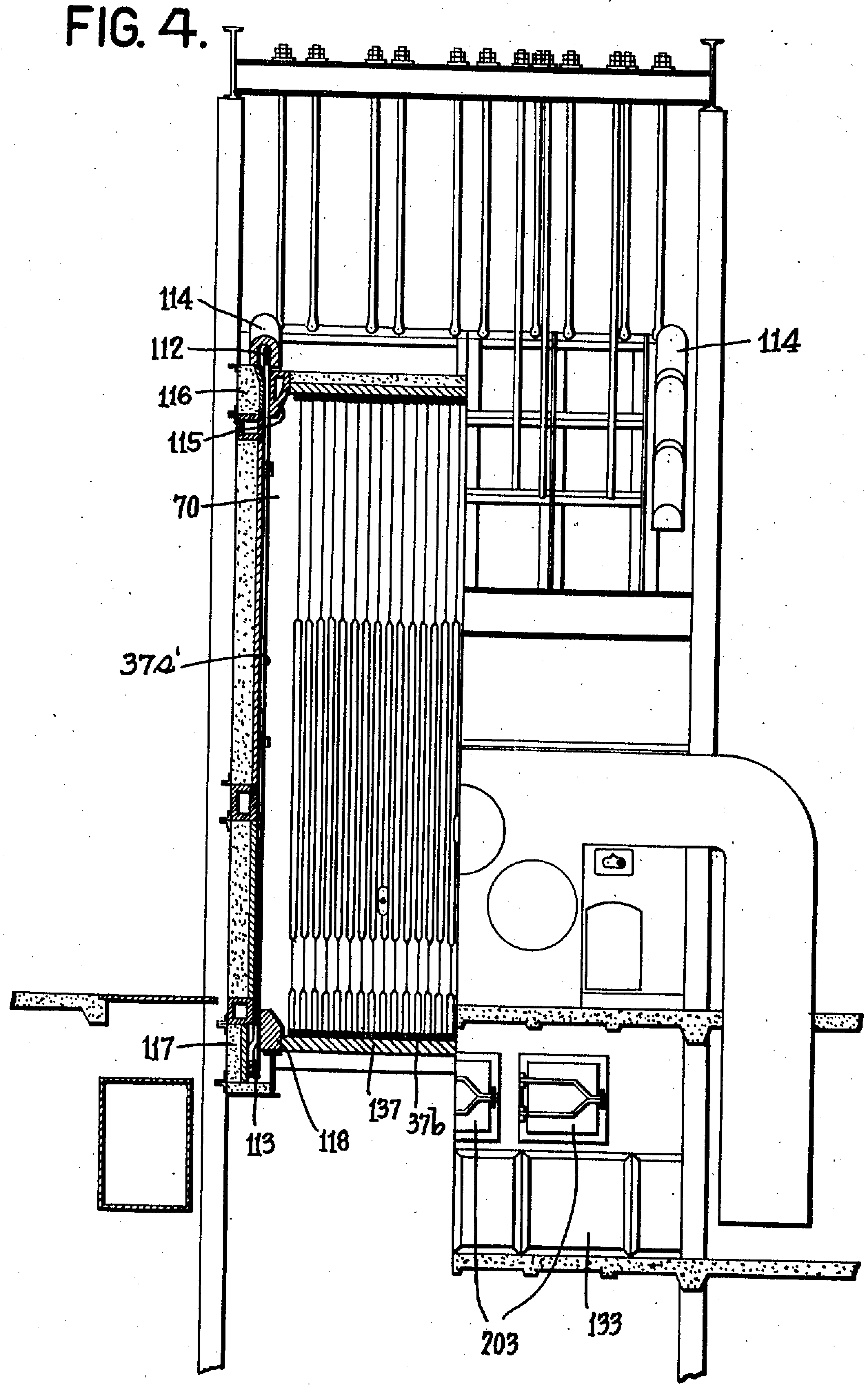
FIG. 4.



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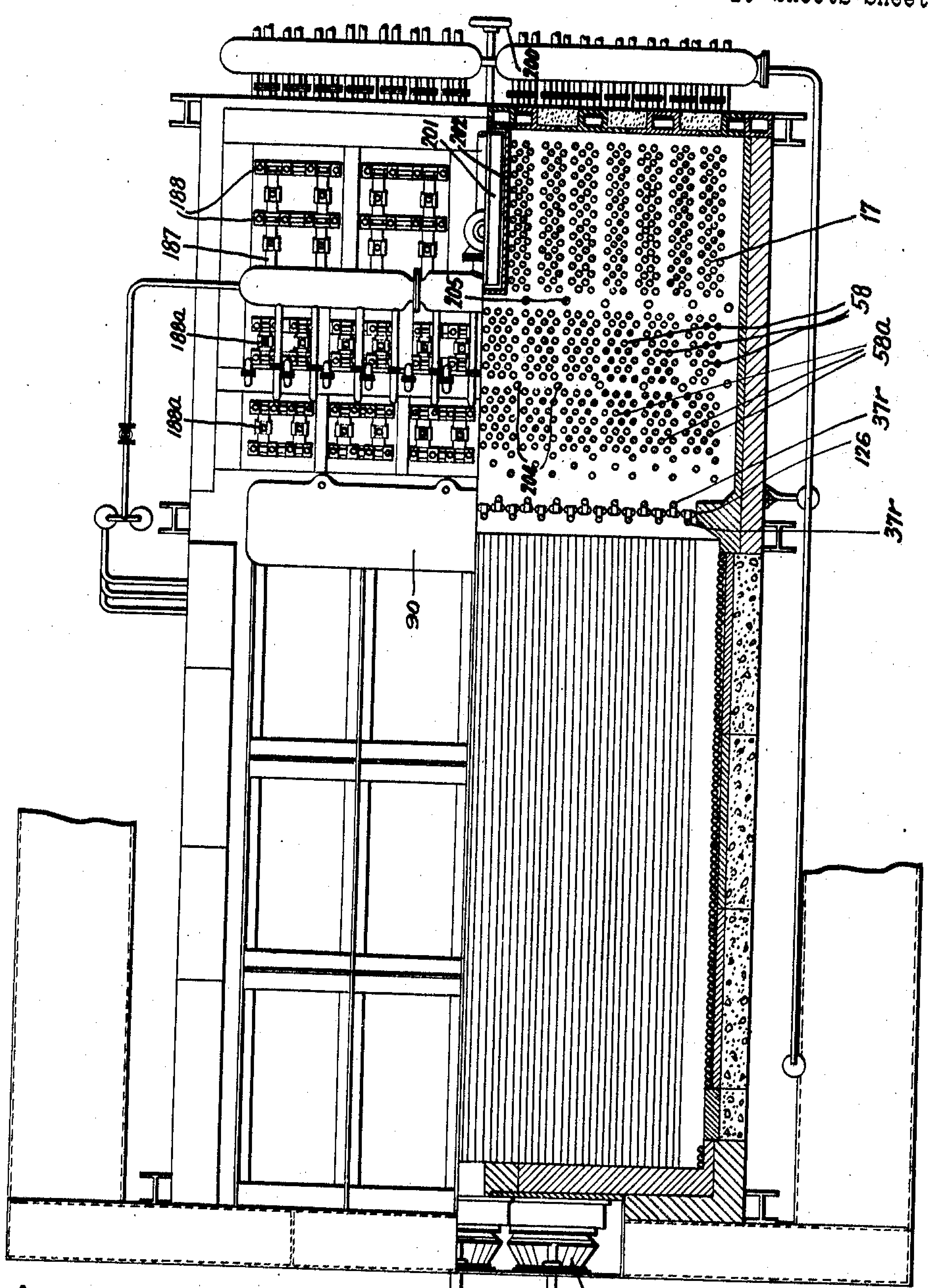

FIG. 5.

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FIG. 6.

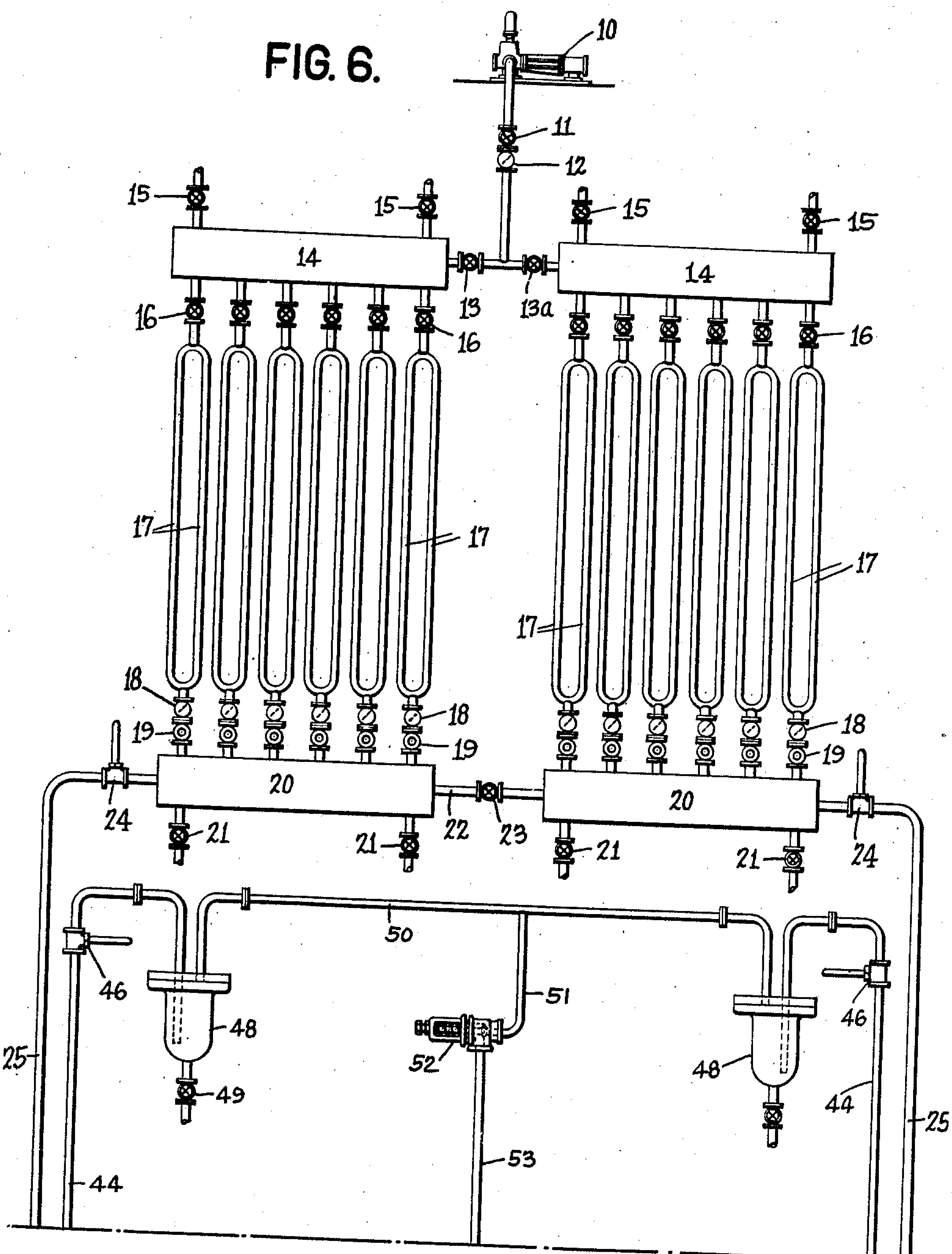

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FIG. 6a.

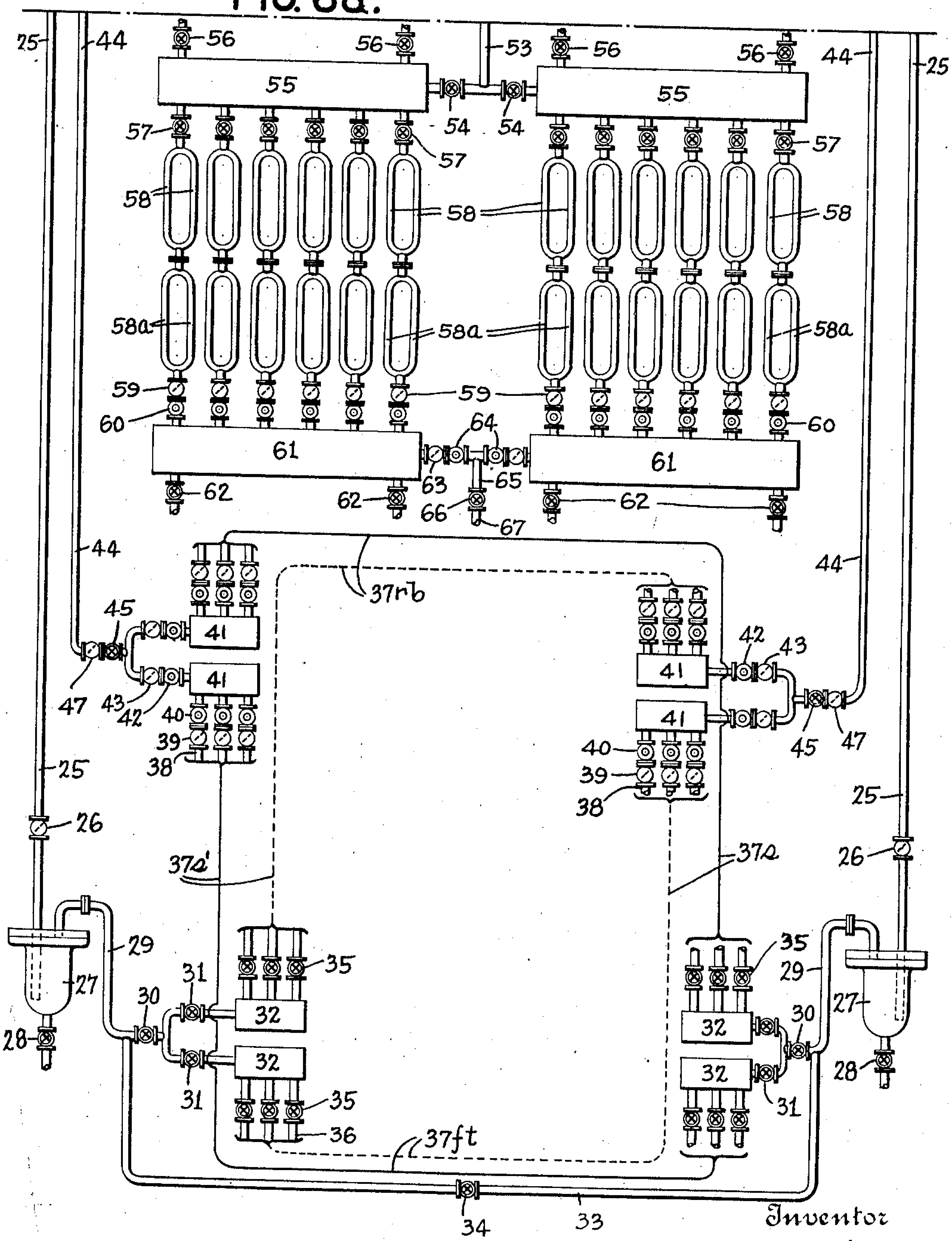

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FIG. 7.

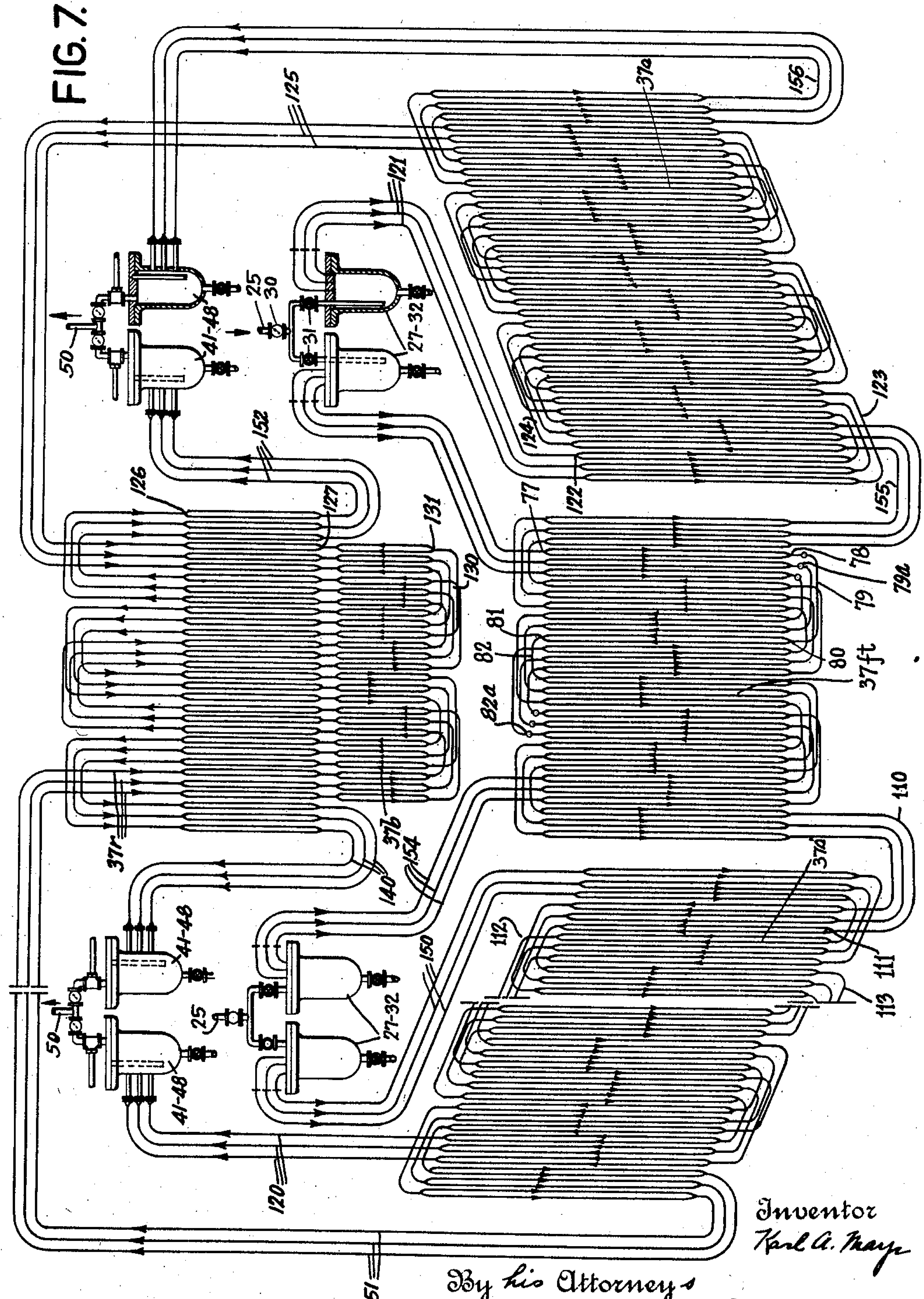

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FIG. 8.

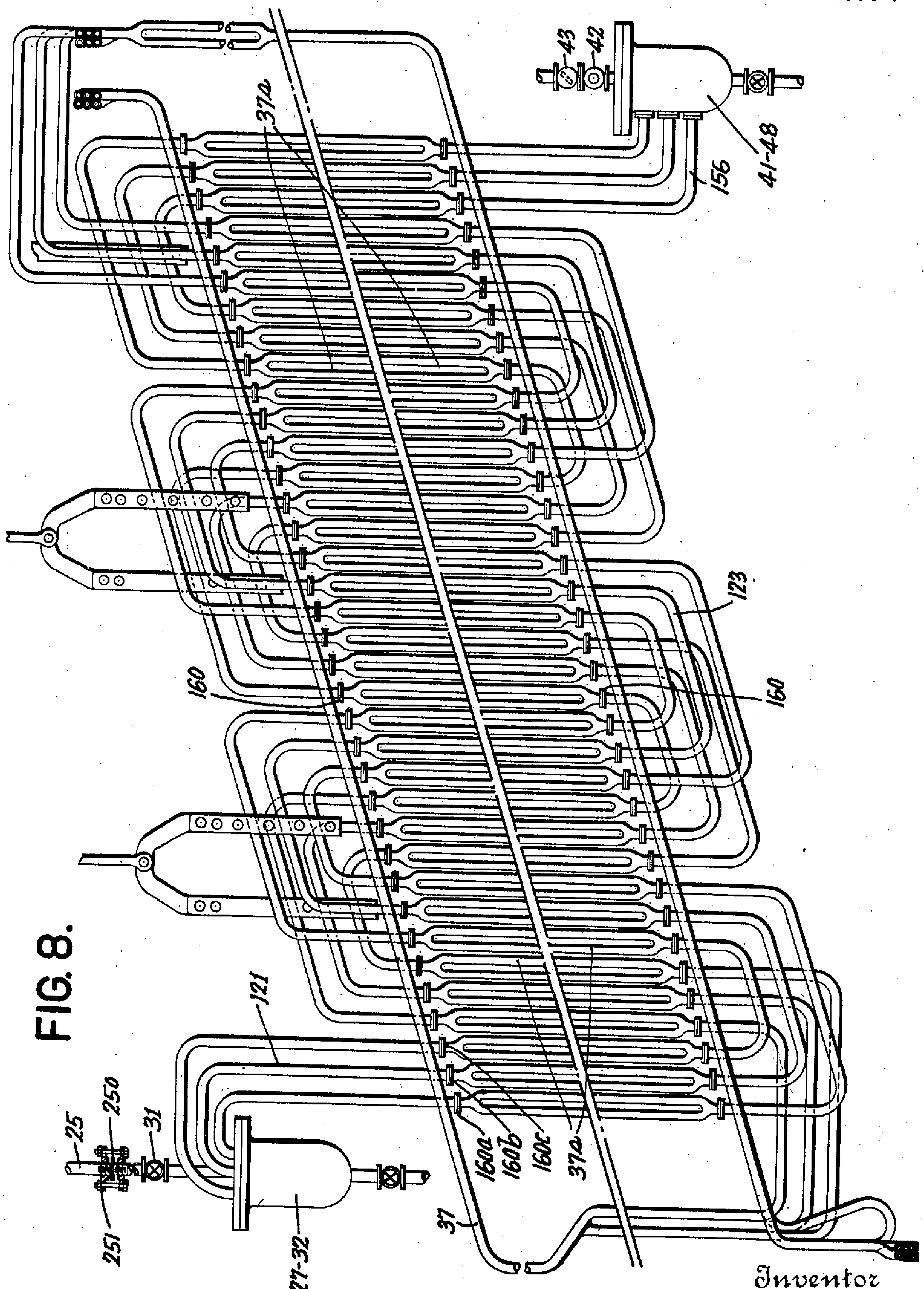

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FIG. 9.

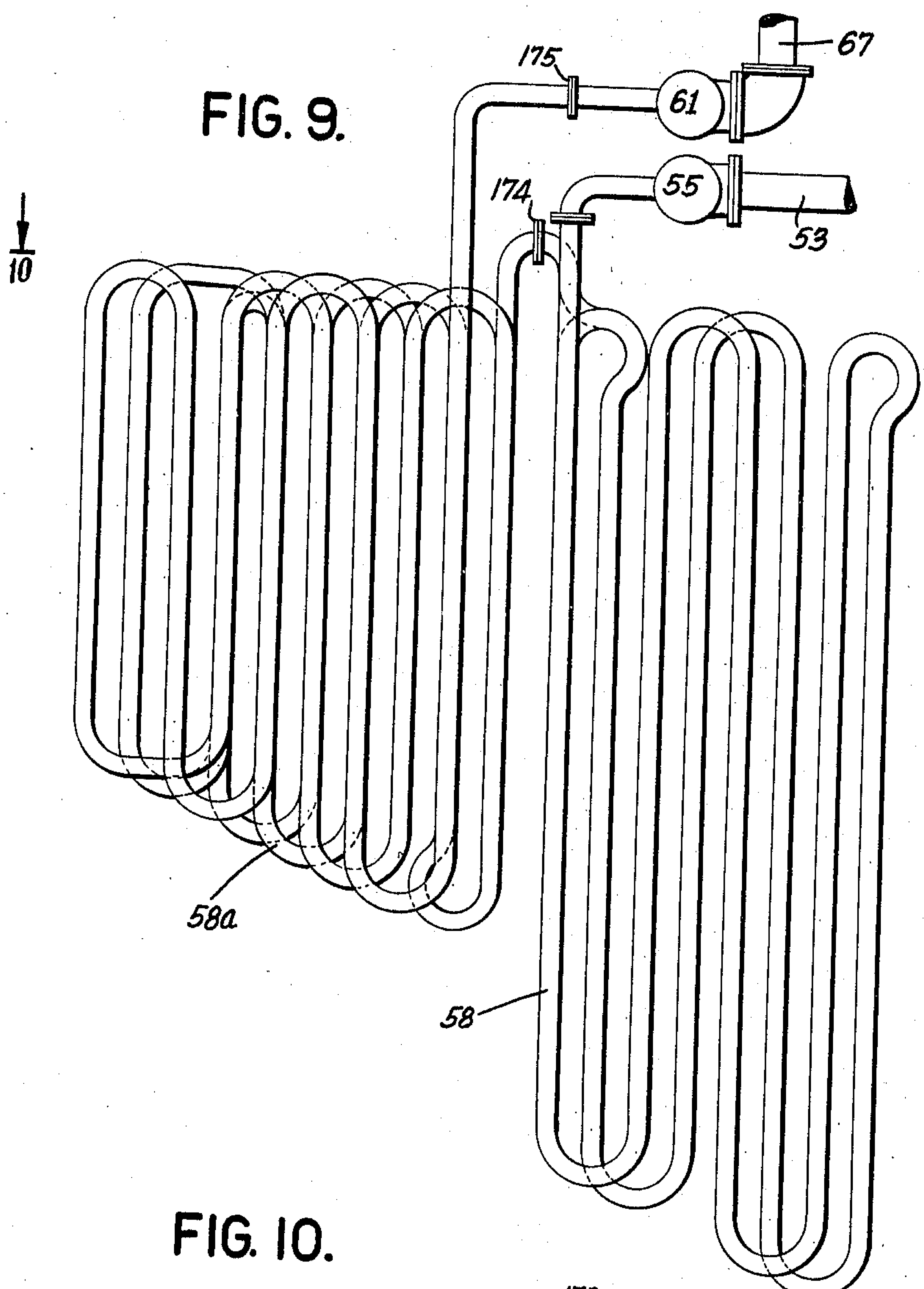

FIG. 10.

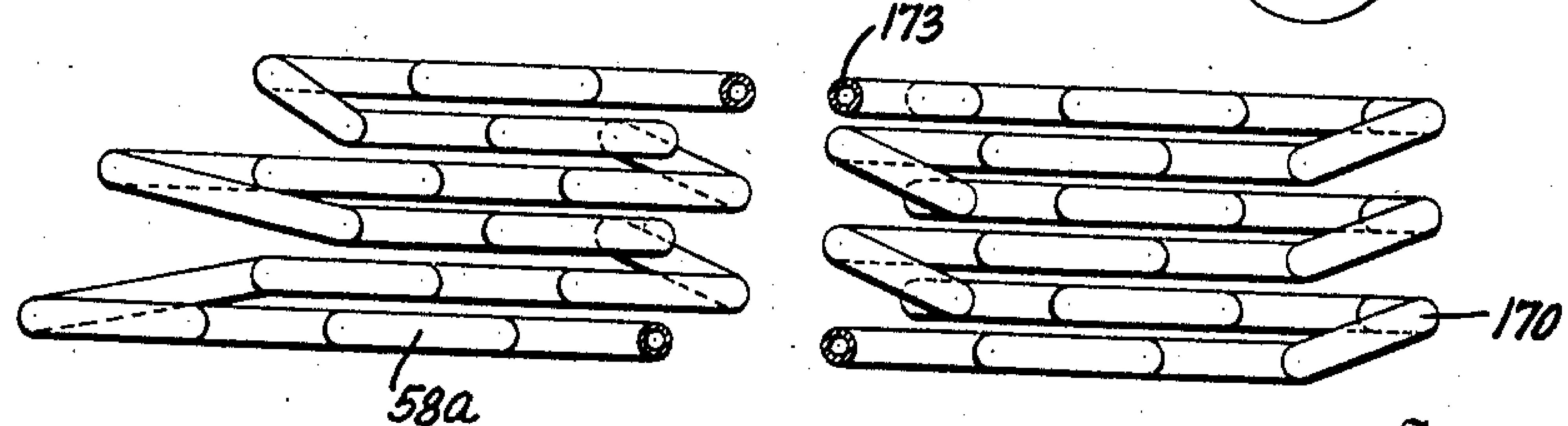

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FIG. 11.

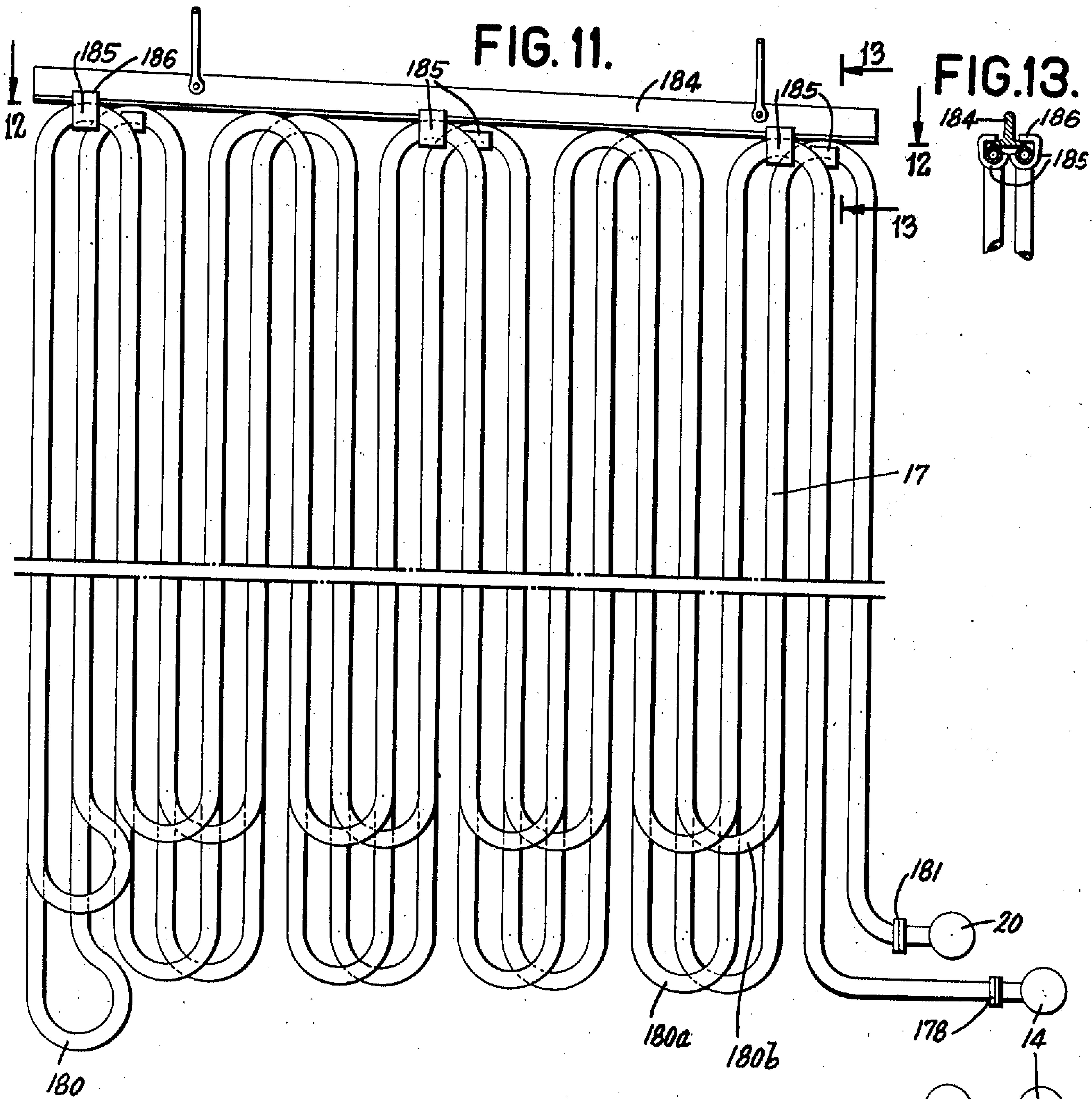

FIG. 13.

FIG. 12.

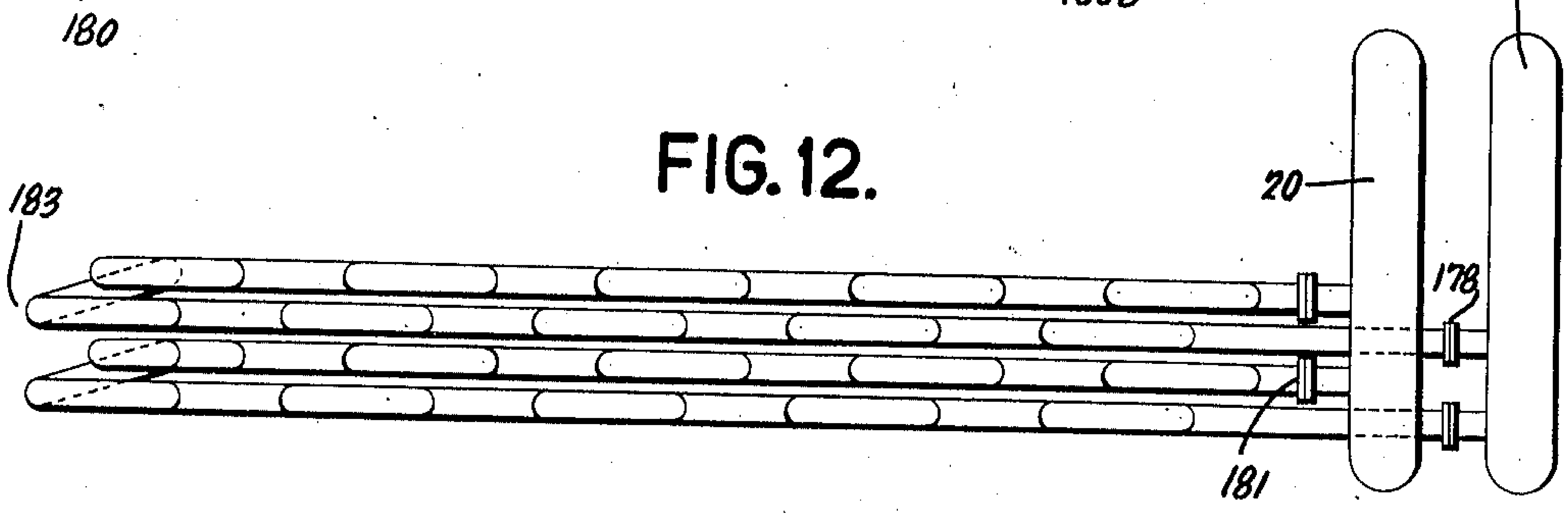

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FIG. 14.

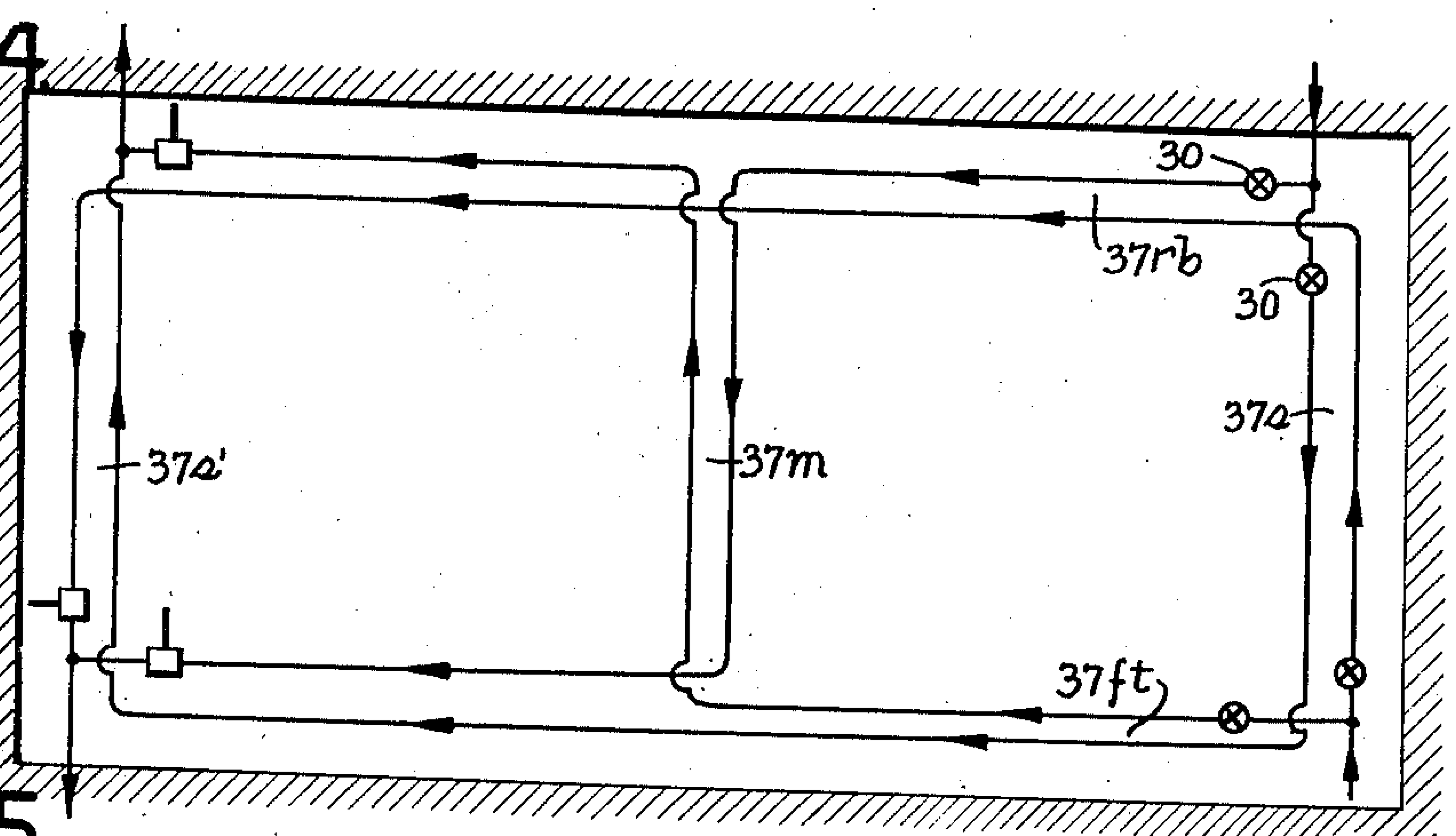


FIG. 15.

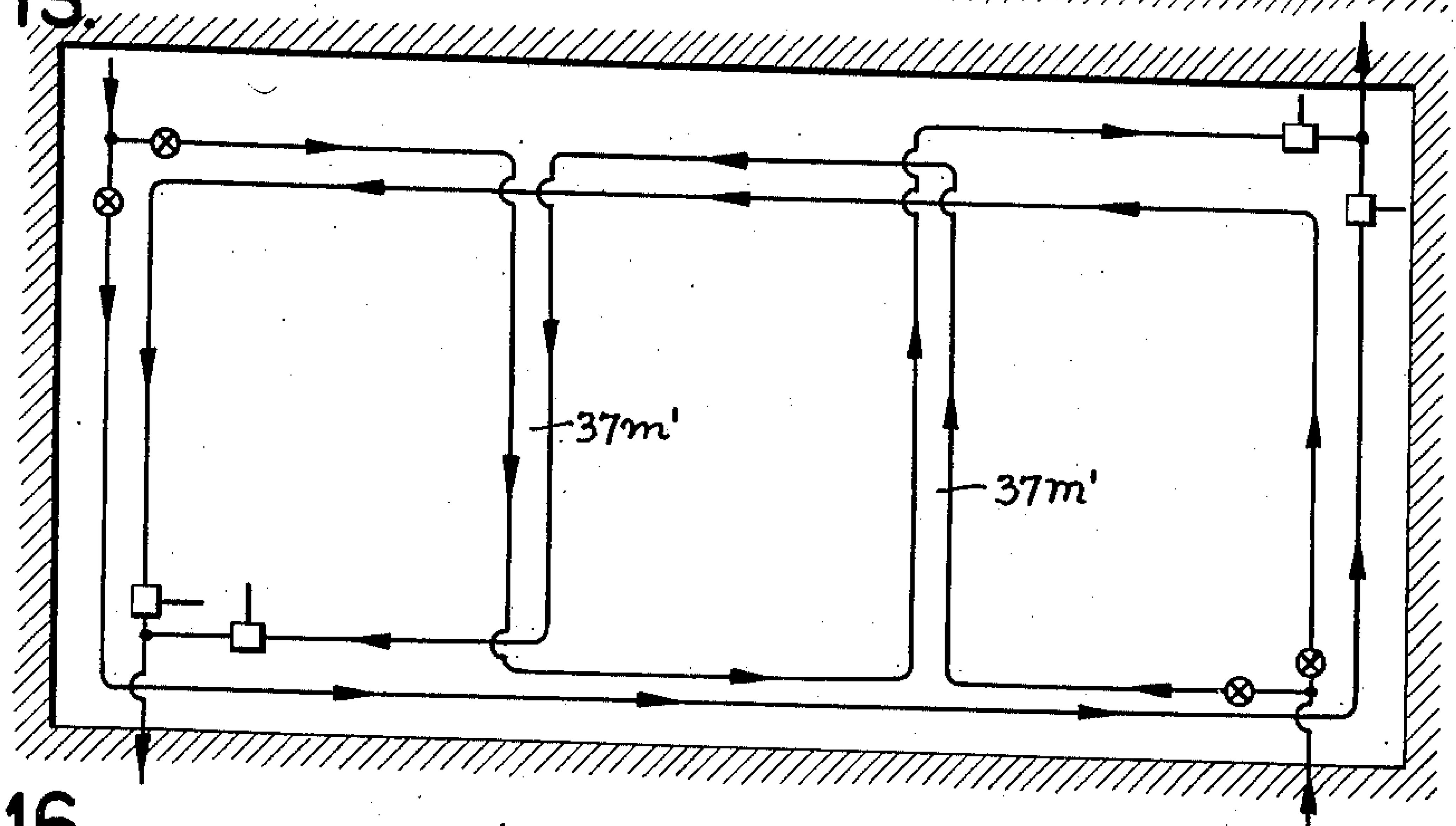
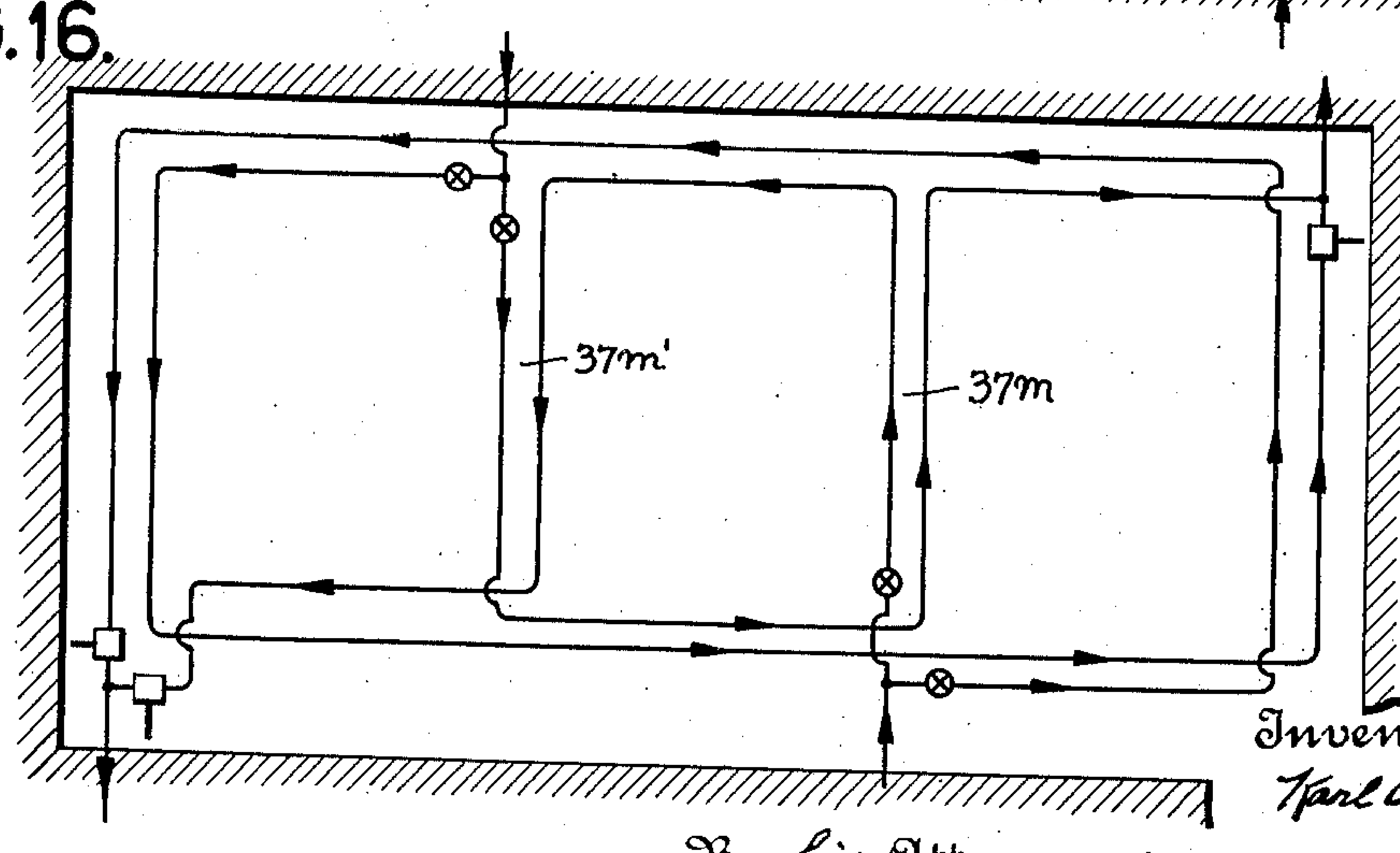


FIG. 16.



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UNITED STATES PATENT OFFICE

1,961,233

STEAM GENERATING APPARATUS

Karl A. Mayr, New York, N. Y., assignor to Siemens - Schuckertwerke Aktiengesellschaft, Siemenstadt, Berlin, Germany, a corporation of Germany

Application July 3, 1929, Serial No. 375,617

17 Claims. (Cl. 122—235)

This invention relates to steam generating systems of the type in which circulation of the fluid is maintained by artificial means and more particularly relates to a generating system for producing large amounts of steam at high pressure and at high superheat temperatures.

One object of the present invention resides in the provision of a construction which will provide for greater heat exchange to be secured with a more compact apparatus than heretofore.

A further object of the present invention resides in the provision of a construction which will provide for abstracting the maximum of radiant heat from the burning gases before such gases impart their heat by convection to heat absorbing surfaces.

A further object of the present invention resides in the provision of a construction in which accessibility of all important parts is secured and also to provide for easy exchange of tubes, tube sections, etc.

A further object of the present invention resides in the provision of a construction in which equal heat absorption may be secured in different individual streams of either liquid or vapor and any flexible adjustability of the rate of heat absorption may be secured as desired and to meet various operating conditions.

A further object of the present invention resides in provision of novel means for mixing the fluid streams at various points in the system to the general end of equalizing the heat absorption effects throughout the system.

Another object of the present invention resides in the provision of suitable separating devices at proper points in the system to remove mud, sediment and scale forming material.

A further object of the present invention resides in the provision of a construction in which parts such as welds, joints, tube bends, headers, etc. are protected or shielded from intense heat.

Further and other objects of the present invention will be hereinafter set forth in the accompanying specification and claims and shown in the drawings, which by way of illustration show what I now consider to be a preferred embodiment of the invention.

In the drawings:

Figure 1 is a transverse sectional view of the boiler superheater and an economizer;

Fig. 2 is a detail sectional view of the bottom row of combustion chamber tubes, the section being taken substantially on lines 2—2 of Fig. 1;

Fig. 3 shows a modified arrangement of bottom tubes;

Fig. 4 is a part sectional and part outside view of the apparatus, the view being taken from the left of Fig. 1 and looking to the right, the sectional part being taken through the apparatus substantially on line 4—4 of Fig. 1;

Fig. 5 is a top view of the apparatus with the portion of the figure to the left being taken substantially on line 5—5 of Fig. 1 and looking in the direction of the arrows and the portion to the right being taken substantially on line 5*a*—5*a* of Fig. 1;

Figs. 6 and 6*a* taken together, show an enlarged and parallel diagrammatic view of the apparatus showing embodiments of the various heat absorbing elements and connecting conduits. This view shows the manner in which the medium to be heated falls from one passage to another and the arrangement of valves, headers, traps, etc.;

Fig. 7 is another diagrammatic view showing in more detail the flow of the medium through the tube sections which form the combustion chamber of the boiler;

Fig. 8 is a somewhat enlarged view of the tube sections which form one of the side walls of the combustion chamber. Such side wall may be for example, the wall which is shown in elevation in Fig. 1 or the opposite wall;

Fig. 9 is an enlarged detail view of the superheater section shown in Fig. 1;

Fig. 10 is a top plan view taken substantially on line 10—10 of Fig. 9;

Fig. 11 is a similar enlarged detail view of the economizer section of the apparatus;

Fig. 12 is a top view of the economizer on which all supporting structure is removed. The view is taken substantially on line 12—12 of Fig. 11;

Fig. 13 is a detail view taken on line 13—13 of Fig. 11. This view shows the manner of supporting the economizer tubes from the top; and

Figs. 14, 15 and 16 show diagrammatically modified arrangements wherein multiple combustion chambers are provided. Fig. 14 shows an arrangement with two combustion chambers disposed side by side and within common outside encasing wall; Fig. 15 is a similar arrangement but with three combustion chambers; Fig. 16 is similar to Fig. 15 but shows a different arrangement of the flow of heating mediums to the various tube sections forming the walls. Each of these views by the parallel lines show the flow of heating medium through the tube sections which constitute the wall portions.

In more detail the understanding of the general features of the present apparatus can best be had from a consideration of diagrammatic Figs. 6 and 6*a*. These views show the complete flow through the apparatus from the feed pump to the steam main where steam is ultimately delivered. (Fig. 6) 10 is the feed pump. From the feed pump 10 relatively cool water passes a shutoff valve 11, thence past a check valve 12 to a branching header provided with individual shutoff valves 13 and 13*a*. 13 and 13*a* connect to suitable pipes which lead to distributing headers generally designated 14. Any number of these distributing headers may be provided. Valves 13, 13*a* also can be used for controlling the distribution of the water into the several headers 14.

It will be understood that any desired number of headers 14 can be provided and that for each header a valve such as 13 or 13*a* will be provided. Each header 14 is provided with the usual blow down valves 15. Extending out from each header 14 are conduits each of which is provided with a controlling valve 16. Beyond valves 16, each conduit branches into a multiple conduit here shown for purposes of illustration as a double conduit designated 17. The individual multiple conduits 17 again merge into a single conduit and each single conduit is provided with a check valve 18 and a thermometer well 19. Beyond the thermometer well the single conduit extends into a collecting header 20. Such collecting headers 20 also may be provided with a conventional form of blow down valves as indicated at 21.

It will be understood that variable and desired distribution of water to be heated to the various headers 14 can be effected by the manipulation of valves 13, etc. The operator of the apparatus can observe the readings of the thermometer in thermometer wells 19 and in the event that certain of the multiple conduits 17 are more favored with heat manipulation can be effected of valves 16 and 13 so that the discharge from all of the sections 17 can be maintained at a substantially equal temperature. In practice, certain of the sections 17 may accumulate more scale than others and this will result in a higher temperature as indicated by a thermometer in 19. Under these conditions the operator can adjust valve 16 to give more water to this section and thus prevent excessive rise in temperature and such additional water also may wash out accumulated scale or sediment in the sections 17.

The various headers 20 are connected with equalizer tubes 22, being provided with controlling valves 23, valves 23 of one section to be shut off from the other when desired but in ordinary operation of the apparatus they are open. The section and part of the apparatus which has heretofore been described constitutes the economizer section of the apparatus.

From the collecting headers 20, the heated water passes thermometer devices 24, thence pass into conduits 25. Thermometer devices 24 permit the observation of the temperature of the water from each associated collecting header 20 and by the observation of such thermometers 24 control of this temperature may be effected by the manipulation of valves 13. Valves 16 provide individual control for the various sections 17 and valves 13 provide collective temperature control for an entire related section.

Referring now to Fig. 6*a*, conduits 25 extend by way of check valves 26 to a separator or mud collector 27. Each mud collector is provided with a valve blow down pipe 28. In each mud collector 27, the conduit 25 extends substantially to the bottom of the collector. At this point there is a sharp diversion of the flow of the medium and the mud collects at the bottom of the trap. The water moves upward in the trap with a slow velocity and finally leaves the trap at conduit 29. Conduit 29 connects to a master controlling valve 30 which branches into multiple conduits each provided with an individual valve 31. In 31 the medium flows into headers 32. The other separator 27 or the multiplicity of separators 27, if such be provided, are connected by suitable equalizing pipes such as 33, pipes 33 being provided with shutoff valves 34 to permit the shutting off of one section of the apparatus when desired. From headers 32 other branch conduits are connected and these branch conduits are individually provided with controlling valves 35. The conduits 36 which are connected to the valves 35 are again branched into multiple branches not shown on Fig. 6*a*, but indicated diagrammatically by the dash lines 37. A subsequent description will give in detail the flow in this path which is generally designated 37 in this figure. The various tubes which constitute the path 37 form various of the walls of the combustion chamber of the apparatus. After passing through these tubular paths 37, individual collecting pipes 38 are again provided, each of which pipes is provided with a check valve 39 and with a thermometer well 40. Beyond 40, the medium is again collected in headers 41. For clarity, the paths 37 have been given suffix reference characters, *f* designates a front wall path, *t* designates a top wall path, character *r* designates a rear wall path, character *b* a bottom wall path and *s* and *s'* are the side wall paths.

It will be understood that multiple sets of distributing headers 32 are provided and that for each set of distributing headers 32 there is a set of collecting headers 41. From the headers 32 at the lower left of Fig. 6*a*, the liquid flows through a path, first designated 37*ft* and thence through a path 37*s* to the collecting header 41. From the distributing headers 32 at the lower right of Fig. 6*a*, the medium to be heated flows through a path 37*s*, through path 37*rb* to the collecting header 41. Medium also flows from 32 at the lower right to a path 37*ft*, thence through a path 37*s'* to header 41. By this arrangement of heat absorbing surfaces a substantial equal amount of heat is received by the medium which passes through the various alternate paths mentioned above, i. e. the heat absorbed in the path 37*ft* plus 37*s* is substantially equal to the heat of path 37*rb* and 37*s*. Also the heat absorbed on paths 37*rb* and 37*s'* is substantially equal to the heat absorbed along path 37*s* and 37*rb* and so on. Beyond headers 41, thermometer wells 42 are provided associated individually with each header and beyond the thermometer wells are suitable check valves 43. Beyond the check valves the multiple headers 41 are again united and in such common conduits 44 controlling valves 45 are provided each having an associated thermometer device 46 associated therewith.

By the above described arrangement of valves in common mains, valves in individual mains, thermometer wells in common mains and in individual mains, a particular selection of control of heat absorption may be secured. Valve 30 pertaining to any one pair of headers 32 for example, can be manipulated in accordance with the reading of the thermometer 46. Valve 31 can be manipulated in cooperation with readings of 42 and valves 35 can be manipulated in accordance with readings on 40.

It will be understood that in practice, certain of these valves and thermometer wells may be omitted. If in a given plant sufficiently careful regulation can be afforded by group control, it may be possible to omit valves 35 and their associated thermometers 40. On the contrary if individual control in each tube line is desired, such group control might be omitted thereby dispensing with valves 31 and thermometers 42 or 30 and 45. The number of controlling valves and associated thermometers will in each case depend upon the accuracy of control which is desired. If sectional control is sufficient individual control can be dispensed with if desired.

Each of the lines 44 is also provided with a check valve 47. The medium which is passed up through conduits 44 is in the form of steam and such steam passes separator traps 48 (see Fig. 6). These traps serve both as mud and water separators and can be provided with suitable blow down valves 49 to remove water and sediment either continuously or periodically. Beyond the separators 48, the medium passes to a common collecting main 50 having a branch 51 extending to a pressure restraining valve, generally designated 52. This pressure restraining valve maintains a higher pressure in conduit 51 and in the preceding sections of the apparatus than in outgoing conduit 53 which leads to the superheater which will now be described.

Referring again to Fig. 6*a*, 53 leads to a branching pipe, each branch being provided with a controlling valve 54. As before distributing headers 55 are provided with blow off valves 56 and with an individual controlling valve 57, selectively controlling the flow through multiple branch conduit paths 58. As shown the multiple branch conduit paths comprise multiple sections such as 58 and 58*a* arranged in series, the connection being made through a single common conduit by a suitable flange or other connection.

As before, individual check valves 59 are provided and each individual pipe is provided with a thermometer well 60. There are also collecting headers 61 provided with blow down valves 62 and with an outgoing controlling check valve 63 and associated thermometer well 64. From 64 the superheated steam passes to a collecting pipe 65 provided with a shut-off valve 66, to control the flow of steam to the main steam main 67. The selected control of flow of the steam through the superheater is afforded as before, viz. there is group control of flow and individual control of flow.

Having now described the general flow of the medium, through the system, reference will be made to the embodiment of the heat absorbing apparatus in a boiler structure and reference will be made to Fig. 1. In Fig. 1, 70 represents the combustion chamber. All the walls of this combustion chamber are formed by tubes, except certain parts of the front wall where there are apertures for the burners generally designated 71. The combustion chamber is of a type which is sutable for using gas, oil or pulverized coal as fuel and for the sake of illustration turbulent pulverized coal fuel burners are shown. The burning gases and products of combustion traverse through the combustion chamber in the direction shown by the arrows, pass over a baffle 72 and enter a superheating chamber generally designated 73. After traversing the tubes 58 and 58*a* of the superheating chamber, the gases pass downwardly and traverse along the tubes 17 of the economizer finally emerging into a duct 74 which may lead to an air preheater not shown. Duct 74 is provided with a dust collecting portion and with a gate valve generally designated 75 for removing collectively accumulating dust.

Fig. 1 shows the various tubes on a very small scale and for a better understanding of the distribution and arrangement of the various tubes, reference will now be made to other figures.

Fig. 7 shows in a developed view all the tube sections which form all of the walls of the combustion chamber 70. On this figure similar reference figures will be used to those previously given in connection with the description of diagrammatic Figs. 6 and 6*a*. It may also be explained that the separators 27 have been combined with the distributing headers 32 and accordingly in this figure 27—32 will designate both a header and a separator. The medium to be heated enters conduit 25, passes valve 30, thence passes through individual valves 31 through the combined separators and headers 27—32 and flows out on the paths indicated by the arrows. On Fig. 7, 37*ft* designates various heat absorbing tubes which are disposed on the front and top of the combustion chamber 70 (see Fig. 1).

It will be understood that a single tube such as 37*f* (see Fig. 1) runs up along the front wall and then bends over and on extended portion of the same tube 37*t* runs along the top wall. Tracing a single tube from 27—32, the single tube extends to a point where the tube is bifurcated and runs into two tubes as indicated at 77 (see Fig. 7). The bifurcated tubes which comprise 37*f* and 37*t* then extend to a point where the bifurcated tubes again unite as shown at 78 into a single tube. This single tube is generally in the shape of a U as indicated at 79 and the end of this tube again bifurcates as indicated at 80, becoming two tubes 37*ft* which finally again unite at 81. Here there is a similar U connection 82 and so on through the system. The various branches 82 and 79 are preferably disposed at a point without the combustion chamber 70 and protected against the intense radiant heat which is radiated within the combustion chamber. Accordingly, the branching portions and U connections can be arranged so as to be readily accessible from without the combustion chamber.

Referring to Fig. 1, the lower U connecting pipes 80 are shown protected by a block or refractory material 83. All the U joints 82 as shown in Fig. 1 are shown without the combustion chamber and in a compartment covered by a removable cover 90. Blocks of refractory material 91 are provided to shield the branching portions and U connections against the intense heat developed in the combustion chamber. The U connections 79 and 82 may be connected to the individual tubes which tubes after being forked or split, form the combustion chamber walls. The U connections may be connected to the tubes in any suitable way as by the flange connections which are shown for other walls in Fig. 8. Or connections may be made by other means such as by welding or suitable union.

The medium to be heated upon leaving the section generally designated 37*ft* again passes through individual lines one of which is here designated 110 (see also Fig. 1) which again branches at 111 into two tubes of the 37*s'* series. The various 37*s'* multiple tubes are likewise provided with upper and lower U connection pipes generally designated 112 and 113. Such upper and lower U pipes 112 and 113 also extend without the combustion chamber and are protected by refractory material against the effect of the radiant heat in the combustion chamber.

Referring to Fig. 4, the upper U pipes 112 are here shown as being disposed in a pocket protected by a cover member 114 and also protected by a lower refractory block portion 115. Such parts 114 and 115 are removable when desired and to remove tubes 37, any desired tube or tubes are cut for such removal. 112 and 114 are accessible from without the combustion chamber 70 as shown in this figure. There is also provided a block 116 which is also removable from without the combustion chamber. The lower U members 113 are also accessible by removing block 117 and such U parts 113 are also shielded from the heat in the combustion chamber by a block 118. It may be explained that the arrangement of the parts is such that all parts of the tubes 37*s* from and including the forks 111 etc. and onward including the U portions 112 and 113 are placed in a protected position without the combustion chamber.

After the medium has traversed through 37*s*′ it emerges in multiple conduits 120 which extend into combined separators and collecting receivers here designated 41—48. The medium leaves these combined separators and collector headers or receivers at 50. From 50 the medium passes to the superheater sections as will hereinafter be described. The path through the heat absorbing tubes 37*s* in the opposite side walls will now be traced.

Leaving 27—32, the medium flows through one of the conduits, generally designated 121, to a branching point 122 as before and thence passes through tubes of 37*s* group through lower U connections 123 then back to other 37*s* tubes through forks and U connections 124. The construction of 37*s*, 123 and 124 is identical to that previously described in connection with 37*s*′ and need not be repeated here.

The medium finally emerges at conduits 125 and enters the tube sections forming the rear and bottom of the combustion chamber which sections have been designated 37*rb*.

Tracing from 125 on Fig. 7 and referring to Figs. 1 and 5, it will be noted that above the baffle designated 72 in Fig. 1, the tubes 37*r* must be spaced apart to provide for free passage of the gases from the combustion chamber into the superheating chamber. Such spacing of parts is afforded in two ways, viz. by spacing the tubes laterally and by an alternate backward and forward bending of the tubes above point 126 as shown in Fig. 1 and also in Figs. 5 and 7. As shown, the pipes 37*r* are provided with the forks 126 and the disposition of these forks is substantially at the point indicated at 126 in Fig. 1. Above this point the multiple tubes extend in single lines and thus provide for a certain amount of open spacing above point 126 between combustion chamber 70 and superheating chamber 73. Inasmuch as multiple tubes are used below the point 126 below the forks, the spacing of the tubes 37*r* in front of the baffle is comparatively close. At the lower end of the double tubes 37*r* which are in front of the baffle 72, the multiple tubes again unite into a single tube, the joint and single tube being indicated at 127 in Fig. 7 and such joint and single tube is similarly shown at 127 on Fig. 1. This joint and single tube portion is accessible from without the apparatus by removing a removable closure plate 128 and the joint is protected against the effects of high intensity heat within the combustion chamber by a protecting block 129. Beyond 127 the single tube is again forked and becomes the multiple bottom tube 37*b* of the combustion chamber (see Figs. 7 and 1). The tubes 37*b* at their forward ends (in Fig. 1) unite into single tubes and are provided with suitable cross U connections designated 130 in Fig. 7. Such U connections and associated forked or joint parts 131 are disposed in a box-like housing generally designated 132 in Fig. 1 and provided with a removable closure plate 133 to permit access to be had thereto from points outside of the combustion chamber. Protection of the tubes adjacent the joints 131 are provided by an inside plate 134 of refractory material. The bottom tubes 37*b* preferably should be so arranged as to provide a flat bottom for the combustion chamber. This flat bottom is desirable in order to facilitate removal of ashes or cinders which may collect on the bottom of the combustion chamber. To provide for such flat bottom with round tubes 37*b* supplemental plates 135 may be provided as shown in Fig. 2. Such supplemental plates can merely rest on the top of tubes 37*b* or if desired they may be bolted in position as indicated at 136 in Fig. 2. If such bolt devices are used, the bolt should be arranged so as to be removable from without the combustion chamber. Disposed below the tubes 37*b* there is provided as shown in Fig. 1, a layer of refractory or insulating material 137. See also Fig. 4. In lieu of using the supplementary plate construction 135 as shown in Fig. 2, the tubes 37*b* themselves may be provided with the special configuration shown in Fig. 3 to afford both a flat top for the bottom of the combustion chamber and also to permit the ready removal of such tubes 37*b* by lifting one tube upwardly from the adjacent parallel tubes. To provide for such removal, it is desirable to provide clearance spacing as indicated at 138 in this figure.

After the heating medium is traversed through the heat absorbing tubes, 37*b*, etc. in the manner indicated in diagrammatic Fig. 7, this heating medium leaves by way of conduits 140 and is received by the separator and collecting header devices 41—48, thence passes out at 50.

The construction of the heat absorbing tubes in all of the various walls, top and bottom of the combustion chamber, has now been described.

It may be explained, however, that there are other streams in said walls which are interspersed in and amongst the tubes previously described to provide other stream flows into the various walls.

Referring to Fig. 7 in the upper left corner of that figure, there are other combined separators and distributing header devices which are likewise designated 27—32. From one of these devices there are provided a number of outgoing conduits 150 which conduits eventually lead down and extend through interspersed tubes of the 37*s*′ group. Such tubes are provided with similar upper and lower headers 112 and 113 to those previously described. The streams which pass through these interspersed tubes 37*s*′ finally emerge at conduits 151 and flow through such conduits back through the 37*r* and 37*b* group where the tubes are interspersed amongst the other tubes of the sets previously described. Upon emerging from 37*r*, the medium passes conduits via 152 to separating and collecting header devices 41—48. The medium leaves the separating and collecting headers via pipe 50. Leaving the right header of the separating and distributing header devices 27—32 shown to the left in Fig. 7, are other conduits 154 which extend to the interspersed tubes of the 37*ft* group. Passing through these tubes connection is made with conduits 155 which in turn connect to the interspersed conduits of the 37*s* group. Merging from this group of tubes are multiple conduits 156 which respectively extend to the right hand of the two receiving and separating devices 41—48 which are shown in the upper right hand corner of Fig. 7.

The various stream flows through the various wall portions of the combustion chamber have now been described.

In practice it will be understood that for cheapness of construction, it is desirable that special shapes of tubes be avoided. The manner of standardizing tube sections and configurations may best be understood by reference to Fig. 8, which shows in an enlarged scale the arrangement of tubes for either the side wall 37*s* or 37*s'*. The configuration for both walls are identical and it will therefore be assumed that 37*s* is shown in this figure. As is here shown all of the central or bifurcated parts of the tubes 37*s* are of equal length and each tube section is provided at its end with suitable coupling flanges 160. The U connection elements 123 and 124 are likewise provided with similar cooperating flanges and by reference to this figure, it will be clear that three different configurations of U shaped parts are sufficient for making all of the desired and necessary connections.

As explained before, these U shaped parts and their cooperating flanges in the apparatus are disposed without the combustion chamber so as to be readily accessible for removal. While flange joints 160 are shown, it will be obvious that welded joints could be used if desired, or any other form of joint may be provided.

While the controlling valves are not shown in in Fig. 8, it is obvious that such controlling valves can be provided in the individual lines if desired. For example, the individual lines 156 can be provided with check valves and thermometer wells such as shown at 39 and 40 in Fig. 6*a*. The ingoing conduits 121 to 37*s* could likewise be provided with valves corresponding to 35 in Fig. 6*a*.

In a more simple embodiment here shown, such individual valves, theremometer valves, check valves, etc., have been dispensed with and in lieu thereof a single valve 31 is provided associated with 27—32 and controlling the flow of steam for the entire group of conduits 121 and upon 41—48 there has been provided a single thermometer well 42 and a single check valve 43.

While the arrangement of valves has been shown on the entrance end of the respective heating sections, it is obvious that such valve could be placed on the exit end as desired. In lieu of using adjustable valves, calibrated orifice plates 250 may be used (see Fig. 8) which may be inserted in the usual way between the flanges 251 connecting to conduit 25 if group control is desired or between the flanges 160*a*, 160*b* and 160*c* if individual control is preferred. These nozzle or orifice plates may also be inserted at the flanges which are at the outlet of the individual sections or at any other flange along the section which may be convenient.

The flow of the medium around all of the various walls of the combustion chamber has now been described. From the combustion chamber, the medium which has now been converted into steam leaves via outgoing conduits 50 (Fig. 7). Leaving 50, the steam passes through conduit 51 as previously described in connection with Fig. 6, thence passes the pressure reducing valve 52 and finally enters conduit 53. Such conduit 53 is also shown on Fig. 9. From 53, the steam passes to header 55 (through valve 54, if such be provided), leaving the header 55 it passes into the first superheater section 58. This superheater section may be made of bifurcated tube elements as shown in Fig. 6*a* or of single tube section as shown on Figs. 9 and 10. It comprises a number of successive loops, the steam passing downwardly through the leg of the first loop, thence passes upwardly, then again downwardly and again upwardly, finally descending in the leg of the loop designated 170 in Fig. 10. It will be noted that 170 is disposed offset relatively to the entering series of loops. The steam then flows through another series of loops and again to the rear through another series and so on. Eventually it emerges at 173 and passes via flange connection 174 (Fig. 9) to the superheater section 58*a*. This superheater is arranged in a similar manner to the superheater 58 previously described and in lieu of having bifurcated sections as shown in Fig. 6*a*, it comprises a single pipe section. The steam finally leaves the section 58*a* through a conduit provided with a flange connection 175 and finally enters the collecting header 61, leaving this header at 67.

As shown in Fig. 5, and also in Fig. 10, the superheater tubes which are forward, i. e. at the left of Fig. 5, are shown spaced relatively far apart. This spacing of the tubes is also shown by Fig. 10. In this way the hottest gases do not enter the compact group of tubes at high velocity. Molten ash particles, etc. are not thrown with too high velocity against the cold tubes which would favor the formation of "birds' nests". As the gases cool down, the space for their travel between the tubes is reduced and a high gas velocity is also maintained through the latter parts of the convection section. This secures a high rate of heat transfer also of these colder sections.

As shown in Fig. 1, superheater sections 58*a* and 58 are independently removable from the top of the apparatus. Usually in practice, it is the 58*a* section which is more often removable and provision is made for removing 58*a* independently of 58.

It will be understood that there are a number of separate sections 58*a* disposed side by side as is shown in top sectional view, Fig. 5. Each of these separate sections of 58—58*a* are separately removable.

To provide for effective distribution of the gas flow through the superheater section 58*a* and the economizer section 17, particularly when the gas flows comparatively slow, baffle devices 176 (see Fig. 1) are provided. Such baffles serve to prevent the gas flowing directly along past the lower end of section 58*a* and direct the gas in a more ordinarily horizontal direction, thus securing a high rate of heat transmission to the tubes of the otherwise dead corner of the upper right of the economizer chamber.

The superheater sections 58*a* and 58 can also be provided with a selective individual or group controlling valves such as have been described heretofore in connection with Fig. 6 and which valves are respectively designated 54—57, etc. and likewise individual or group thermometer wells and check valves may be provided.

The economizer section will now be described. Referring to Figs. 1 and 11, 14 is the inlet header, in this header by suitable flange connection 178, connection is made to the first coil or loop of the economizer 14. The water flows first upwardly, then downwardly, upwardly and downwardly, upwardly and downwardly, upwardly and downwardly, upwardly and downwardly to a point designated 180, which is the bottom loop of the first of a series of loops which extend back and connect through flange 181 with a header 20. Also connecting into header 14 is another series of economizer pipes generally designated 183 in Fig. 12. To support the loop tubes of the economizer and for also supporting the loops of the superheater, preferably the construction shown in Fig. 13 is provided. In this figure, 184 is a T beam. There is one such T beam 184 provided for the economizer 17, another for the superheater section 58 and another for the superheater section 58a. The various loops and coils of the economizer or superheater are supported from such T beams 184 in the manner shown in Fig. 13. A number of hooked members 185 are provided which hook into the coils and have a portion standing over the flange of the T beam. They can also have a part 186 hooking into an aperture into the T beam to prevent their shifting with respect to the T beam. The T beam 184 pertaining to the economizer is suspended from a cross beam 187 (Fig. 1). Such cross beam 187 is in turn suspended by a pair of links 188 from a main overhead beam 189. For suspending the sections of the superheater suspension beams similar to 187 are provided and inasmuch as these beams 187a are of relatively short length a single suspension rod 188a is sufficient for suspending each of the suspension beams 187a from the main supporting beam 189. The tubes forming the walls of the combustion chamber can be supported at any suitable and desired manner and preferably such tubes should be so supported that they can be arranged in groups.

Referring again to the economizer (Fig. 11), it will be noted that there are certain loops 180a which are relatively long, whereas other loops as indicated at 180b are relatively short. The long loops 180a are in one row and the relatively shorter loops are in the next adjacent row. Thus there is an alternation of long loops and short loops which obviates a free exit space adjacent the outlet ducts 74 and obviates the possibility of clogging the economizer at this point. It also prevents excessive heat transferred to the economizer at the lower loop portions. This point in the system is the coldest point and there is accordingly, little possibility of damage to the tubes at this point, but to obviate the possibility of damage to the tubes the long and short loops are provided.

Figs. 14 to 16 inclusive, show modifications of the stream flow and arrangement of tubes which may be employed when very large combustion chambers are required.

According to the arrangement shown in Fig. 14, the combustion chamber is divided into two parts and the separation of this combustion chamber into two parts is afforded by center tubes which are generally designated 37M in the figure. By providing the tubes arranged in this manner, additional heat absorbing surfaces are provided in the combustion chamber. The tubes 37M are exposed at both sides to the radiant heat of the burning gases.

Fig. 15 shows another modification in which there is a combustion chamber provided with two such sets of intermediate tubes 37M and 37M' thereby dividing the combustion chamber into three parts instead of two as in Fig.14.

Fig. 16 is an arrangement generally similar to that of Fig. 15, but with a different path of circulatory flow through the various tubes and heating sections. All of the modified arrangements shown in these views, embody the general principles previously set forth, that is multiple streams in parallel with each other are provided and the extent of flow and extent of heating surfaces in the various parallel streams is substantially equal or equivalent. This can be readily traced in any figure by gauging the extent of flow of the stream lines and taking into consideration the character of walls concerned.

Referring now to Figs. 1 and 5, 200 is a hand wheel for operating a controlling damper, generally designated 201. The damper 201 is provided in a box-like conduit or casing 202 which takes the place of one of the tube sections 17 of the economizer. By partially or wholly opening up the damper 201. A certain amount of the hot gases can emerge directly to the flue 74 through the box 202 instead of traversing over the economizer tubes. By varying the position of the damper it will therefore, be apparent that the amount of heat absorbed by the economizer can be controlled and varied as desired. For example, if the feed water temperature entering the economizer is relatively high, it will be unnecessary to absorb as much heat in the economizer. In other cases, the proportionate heat absorption in the economizer and superheater may be not as desired and it will be then possible to reduce the heat absorption or increase the heat absorption in the economizer to a certain extent.

Referring again to Figs. 1 and 4, 203 represents ash removal doors which are disposed adjacent to the bottom tubes 37b. In Fig. 1, this door is shown merely as an opening designated 203, but it will be understood that this opening is closed by metal doors as indicated at 203 in Fig. 4. By opening one or more of these doors 203, ashes can be readily removed from the sloping bottom. The slope of the bottom towards the doors tends to deflect the ashes down to the lowermost point adjacent the door so that the ashes can be readily removed when desired.

As shown in Fig. 1, the shape of the combustion chamber is generally such that desirable flame propagation and dispersion of the burning gases is secured. In passing through the combustion chamber, the flames first sweep in horizontally, they are thereafter diverted generally upwardly and subsequently sweep again in a horizontal direction and outwardly from the combustion chamber into the superheater.

By the provision of the exit opening at the side and the upper part of the combustion chamber, a better gas flow is obtained than heretofore because unburned fuel particles which may be thrown towards the top wall of the combustion chamber have an opportunity to fall back by gravity without resistance into the center of the flame. Such an operation did not heretofore take place with constructions where the gas outlet was at the top of the combustion chamber.

It will be understood that suitable soot blowers may be provided when desired and such soot blowers may be placed in the open spaces between sections 58 and 58a of the superheater as indicated at 204. Other soot blowers 205 can be arranged to free the economizer 17 of soot in the opened space. These soot blowers 205 also serve to remove soot from the rear of superheater section 58.

According to the present construction, the headers and collectors intermediate the various heating sections can be made of sufficient size to provide a certain storage capacity intermediate the various sections. The construction, however, is such that the use of large receiving drums is obviated. In lieu of using one or more very large receiving drums at the upper part of the apparatus as is necessary with natural circulation of boilers, it is possible with the present construction to use relatively small diameter headers and ultimately to obtain the same storage capacity that would be obtained with large receiving drums. Economy of construction is also secured because it is easier to provide the proper strength in a small diameter header than with a large diameter drum. Furthermore, the headers are disposed at various points about the apparatus where space is available and there is no specific restriction as to the location of the various headers as is the case with drums in natural circulation boilers. Furthermore, the headers are so disposed as to be readily accessible for inspection or repair.

What I claim is:

1. A steam generator comprising a series of tube sections, means connecting a number of tubes to form a group and a number of other tubes to form another group, said means including a distributing header for each group and a collecting header for each said group, a conduit connecting the distributing header of one group with the collecting header of another group, and a plurality of said groups being arranged in parallel relation with each other and each conduit having flow controlling means associated therewith to provide for equalization and adjustment of the flow through various parallel groups.

2. The invention set forth in claim 1 in which equalizing conduits are provided connecting a header of one group with the respective header of another respective group to equalize the pressure in the said headers.

3. A steam generator with a combustion chamber and water and steam walls therefor formed of heat absorbing tubes, means connecting the tubes to provide for a plurality of parallel streams of flow for the medium to be heated, each said stream being directed first over one vertical wall and then in succession over other vertical walls, means for distributing the flow of the medium through the tubes upon various walls so that the amount of heat absorption of one parallel stream is the same as the amount of heat absorption of another parallel stream.

4. A steam generator having heat absorbing tubes disposed to form the walls of a combustion chamber, means for directing a stream of the medium to be heated first through tubes upon one wall and thereafter directing said stream through tubes upon two other walls, and means for also directing another parallel stream first over one wall and thereafter over another wall.

5. The invention set forth in claim 4 in which the tubes and connections therefor for one parallel stream and the tubes and connections for another parallel stream are so coordinated to each other that the amount of heat absorbed in the different parallel streams is substantially equal.

6. A steam generator including a number of tube sections, each section comprising a plurality of individual tubes connected in parallel, means connecting a plurality of said sections in parallel to form groups of sections (37—37), means serially connecting said groups of sections individually with other tube sections (17), and mud collectors disposed intermediate said groups of sections and said serially connected sections.

7. A forced circulation steam generator comprising groups of tube sections, each section comprising a plurality of individual tubes connected in parallel by inlet and outlet headers, conduits serially connecting the inlet headers of one group with the outlet headers of another group and mud collectors interspersed in said conduits and separate from the aforesaid inlet and outlet headers.

8. A steam generator comprising a combustion chamber, and means comprising a plurality of tube sections defining the walls of said chamber, each tube section comprising a plurality of individual tubes which are connected in parallel to form said tube sections, and means directing the flow of the medium to be heated first in one direction along a wall through one tube section which comprises a plurality of individual parallel connected tubes and then in the opposite direction along said wall through another tube section which comprises a plurality of individual parallel connected tubes.

9. The invention set forth in claim 8 in which the tube sections are connected in groups, a plurality of said groups being provided upon each wall and said groups being interspersed with each other along said wall.

10. A steam generator comprising a combustion chamber, means comprising individual tubes connected in parallel and forming tube sections, means connecting a multiplicity of said sections to form a vertical heat absorbing wall and to provide for the flow of medium to be heated first upwardly through one section and then downwardly through another section upon the same vertical wall and means connecting the multiplicity of tube sections upon one wall with another multiplicity of tube sections upon another wall.

11. A forced circulation steam generator having a plurality of combustion chambers with heat absorbing tubes defining the walls of said plurality of combustion chambers, means interconnecting said tubes to form sections of parallel arranged tubes, and means for serially interconnecting said sections to direct a flow of medium to be heated first through the heat absorbing wall sections of one chamber and then through the heat absorbing wall sections of another chamber.

12. A forced flow wall tubular steam generator comprising a plurality of combustion chambers, heat absorbing tubes defining all of the walls of said plurality of chambers, header means to connect a plurality of tubes to form sections of parallel arranged tubes, means for splitting the flow of the medium to be heated into separate streams and for distributing said streams into the sections forming different walls of the combustion chambers and for causing each separate stream to flow through walls of different combustion chambers, and means for reuniting the various streams after they have passed through the walls of the combustion chambers.

13. The invention set forth in claim 12 wherein control means are provided for regulating the amount of flow through the several streams to assure an equal heat absorption by all of the streams and wherein certain sets of the plurality of tubes define a common heat absorbing wall for a plurality of the combustion chambers.

14. A forced flow tubular steam generator com-

prising a plurality of combustion chambers, heat absorbing tubes defining all of the walls of said plurality of combustion chambers, means for distributing the flow of the medium to be heated into a plurali y of separate streams which flow through the tubes forming the various combustion chamber walls, said distributing means providing for each separate stream to flow through the walls of different combustion chambers and means correlating the tubes and the locations thereof so that each of the several separate streams passes over substantially an equal amount of heat absorbing wall and encounters substantially equal heat absorbing conditions as another of the separate streams.

15. A steam generator including a number of tube sections, each section comprising a plurality of individual tubes which in a single section are themselves connected in parallel, means connecting a plurali:y of sections in parallel to form a group of sections and means connecting another plurality of sections in parallel to form another group of sections, means connecting the aforesaid plurality of groups of sections with another group of sections, and mud collectors individually disposed intermediate each parallel connected plurality of sections and the other group of sections which are connected therewith.

16. A steam generator with two parallel paths for flow of a heating medium therethrough, each parallel path including a group of tube sections which sections are connected in parallel, each tube section comprising a plurality of individual tubes which in a single section are themselves connected in parallel, another group of the tube sections which are also connected in parallel with each other and in series with the first mentioned parallelly connected group of sections and mud collectors interposed in each of the first mentioned parallel paths and between the first mentioned group of sections and the second mentioned group of sections.

17. A steam generating apparatus comprising a plurality of heat absorbing tubes arranged in parallel relation to each other for parallel flow of the medium therethrough, means also connecting the tubes for further sub-dividing the same into groups of sections which are also in parallel relation with each other, means for adjusting the flow individually to each group and separate flow controlling means for adjusting the flow individually in and through each tube section.

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