

Dec. 8, 1931.

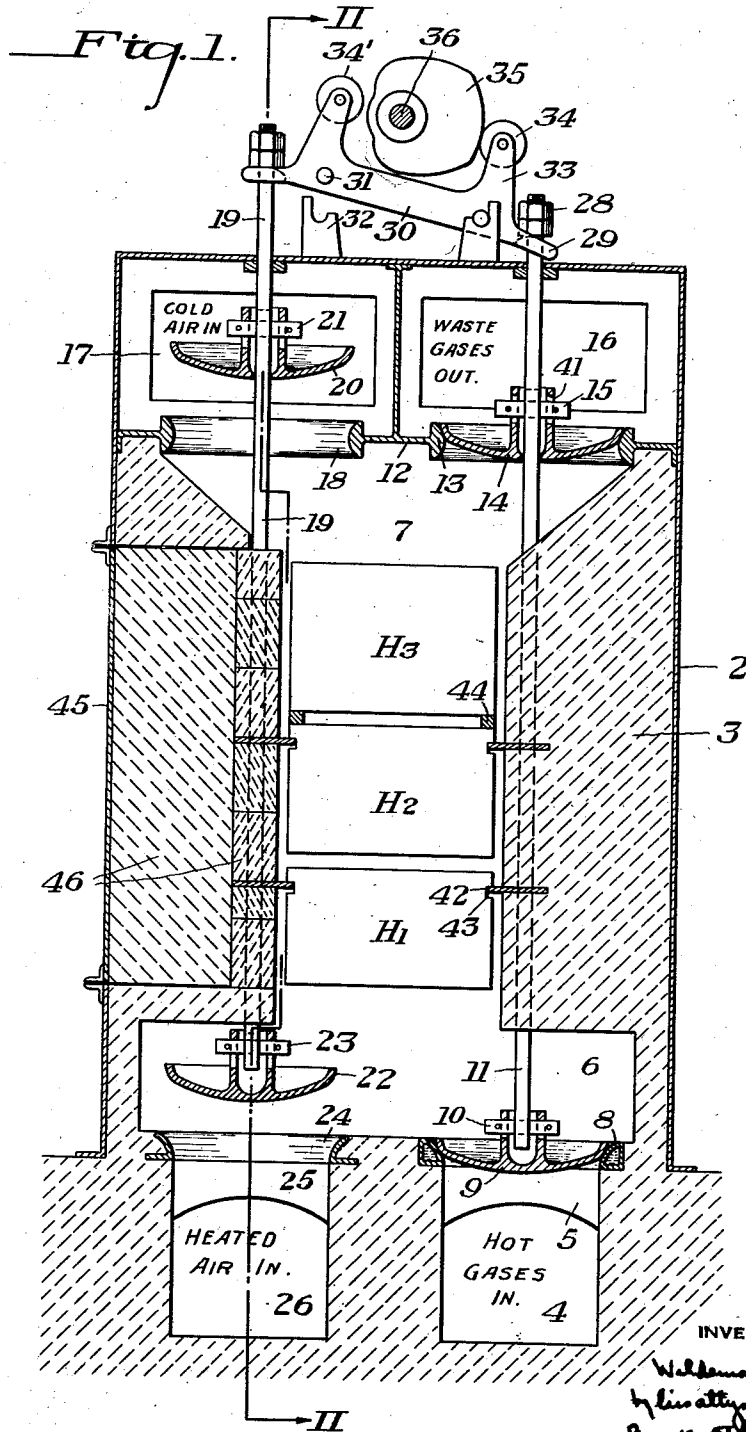
W. DYRSSEN

1,835,148

HEAT EXCHANGER

Filed Jan. 26, 1928

8 Sheets-Sheet 1.



Dec. 8, 1931.

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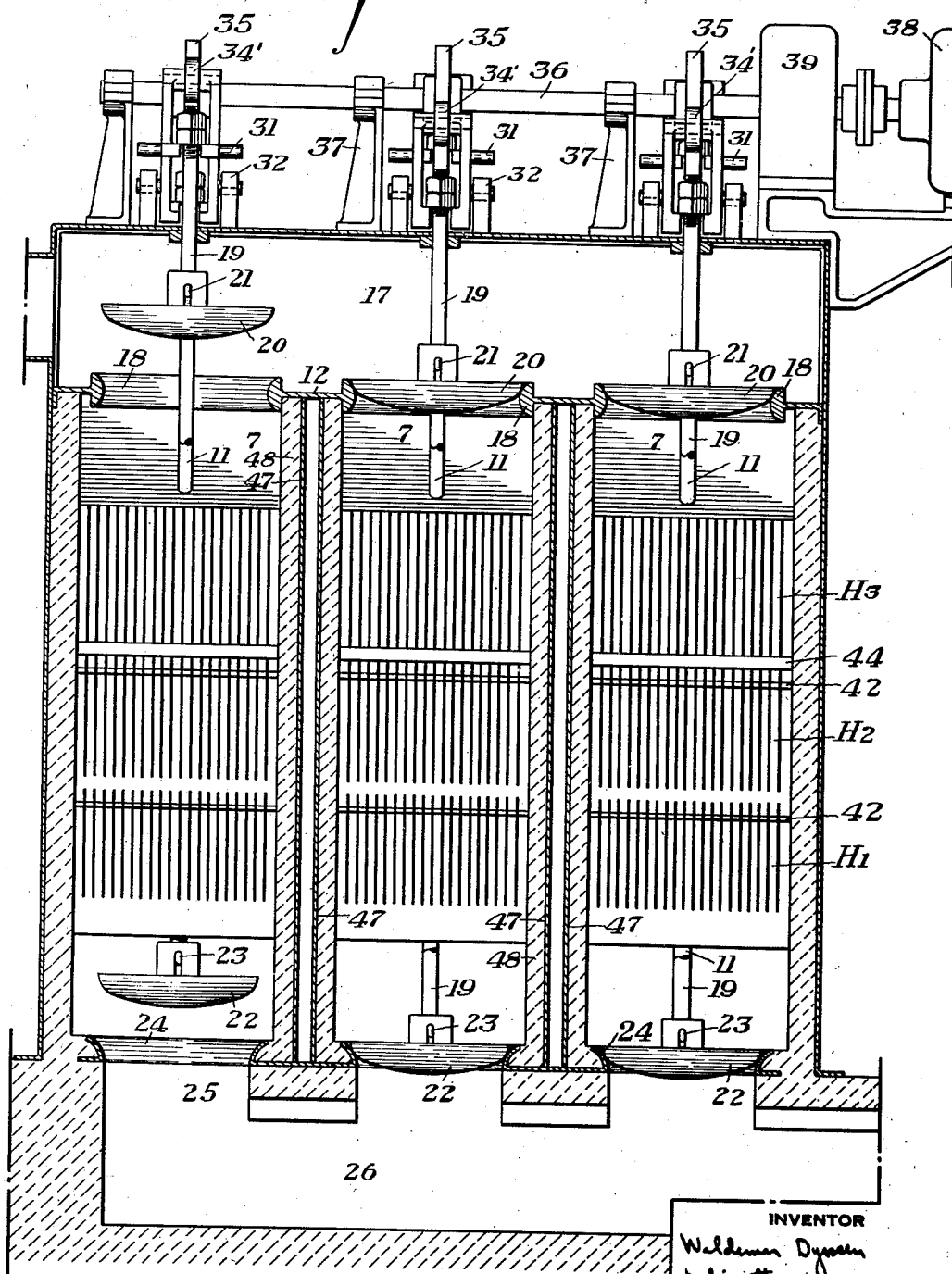
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HEAT EXCHANGER

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8 Sheets-Sheet 2

Fig. 2.

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HEAT EXCHANGER

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Fig. 4

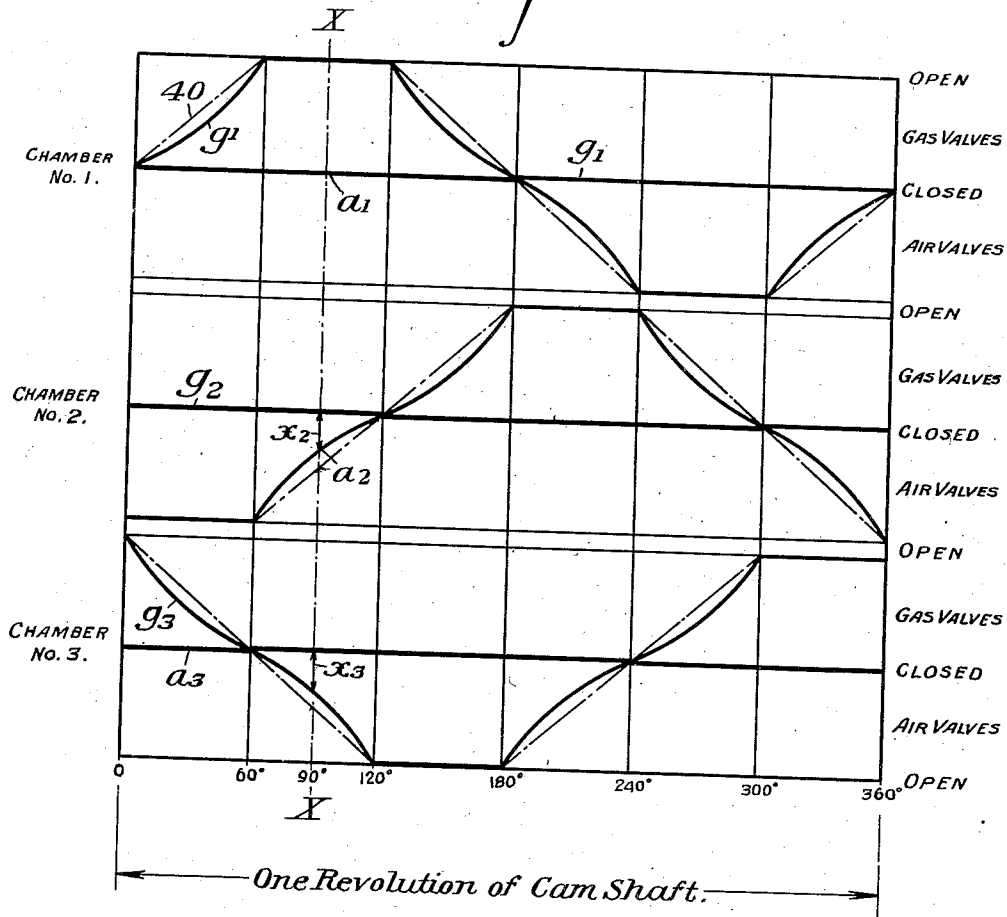
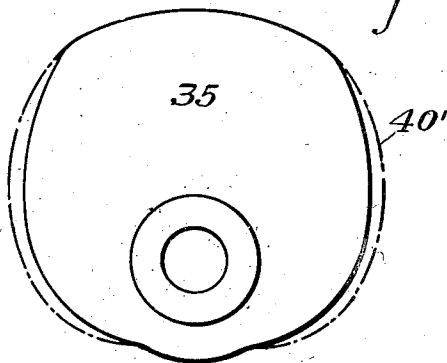


Fig. 3.



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Fig. 5.

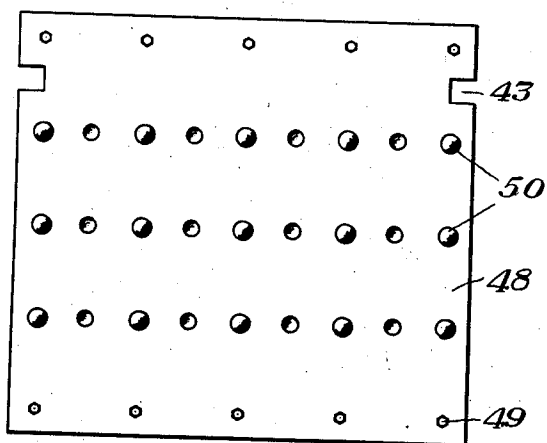


Fig. 6.

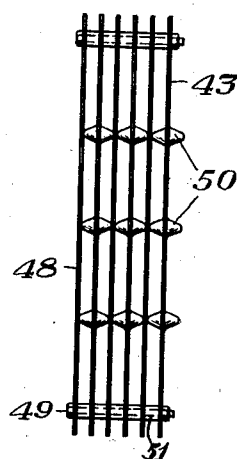


Fig. 7.

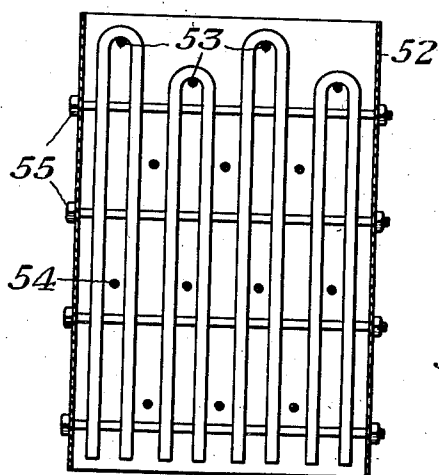
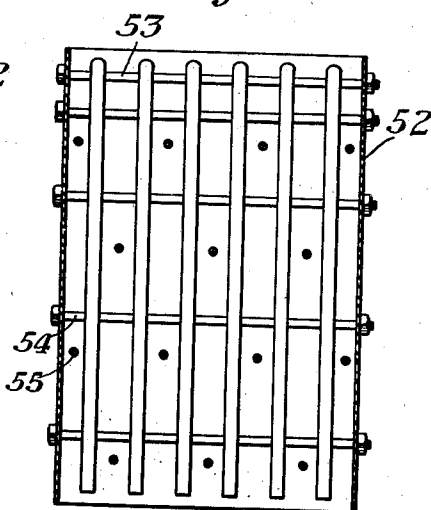


Fig. 8.



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Fig. 9.

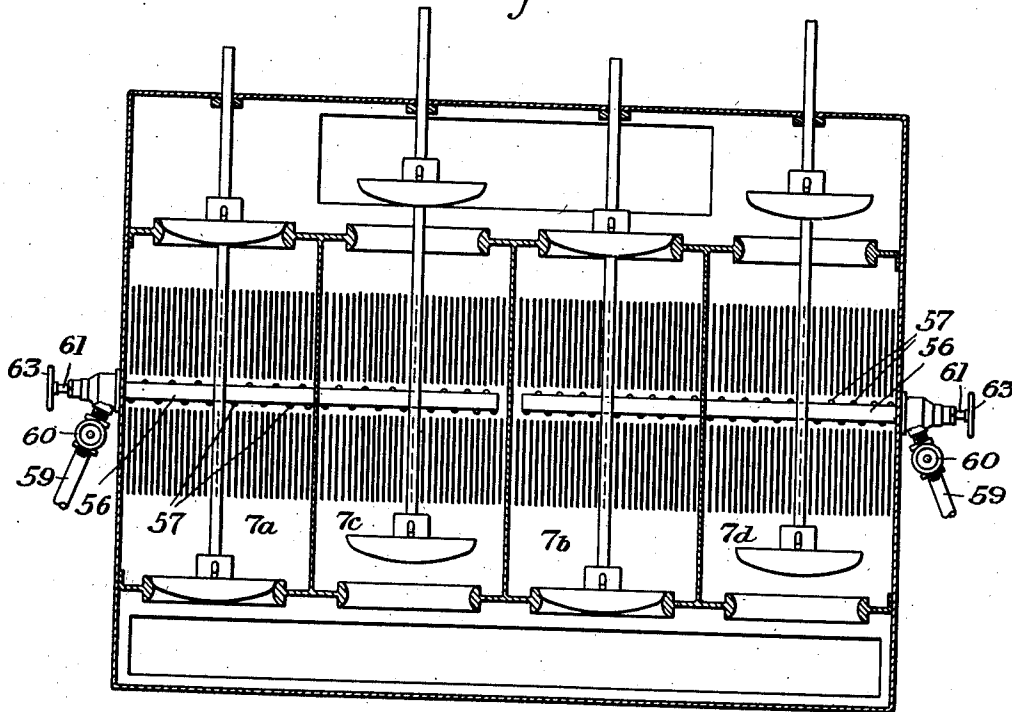
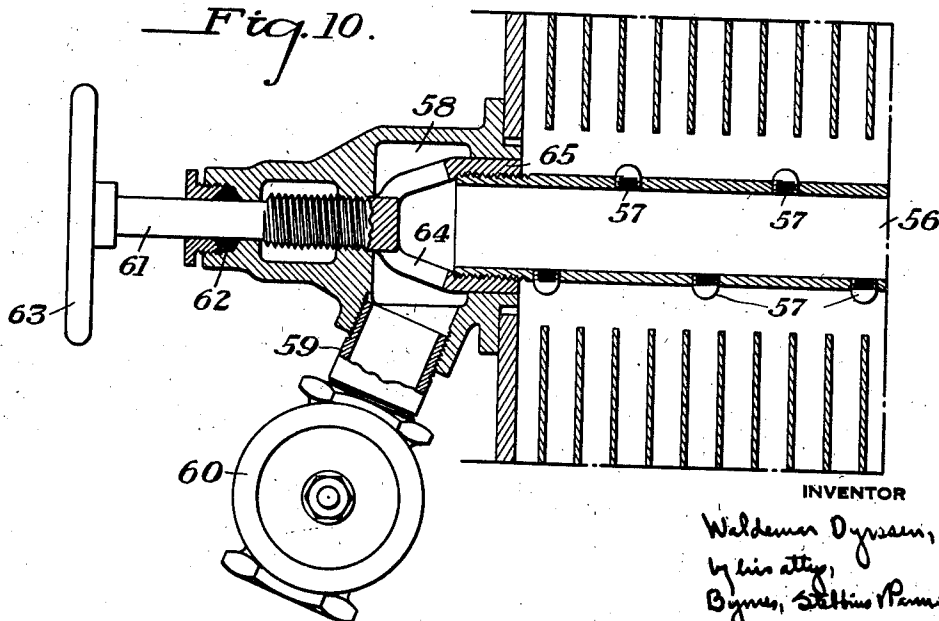


Fig. 10.



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Fig. 12.

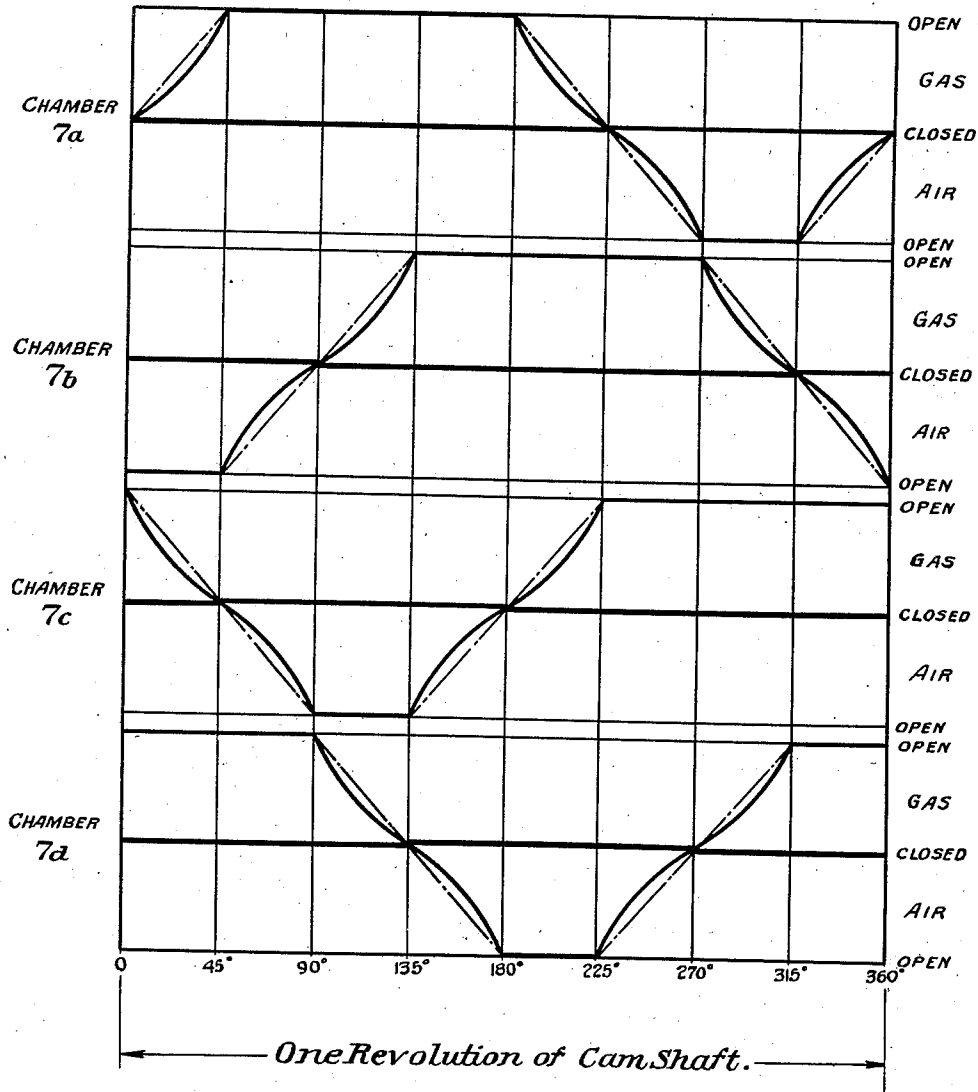
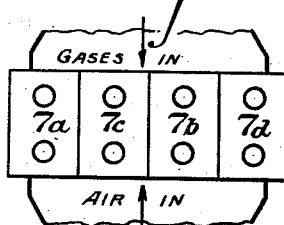


Fig. 11.



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Fig. 14.

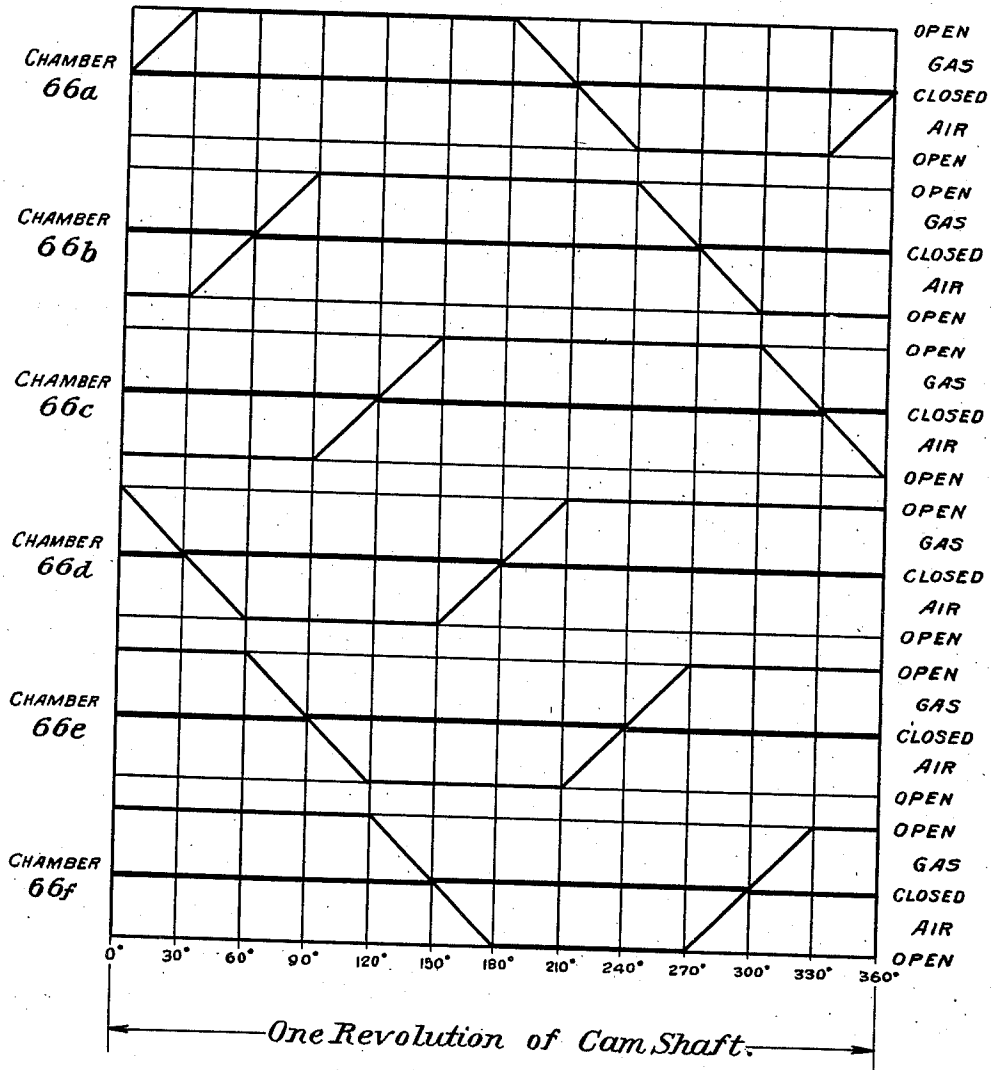


Fig. 13.

○	○	○	○	○	○
66a	66d	66b	66e	66c	66f
○	○	○	○	○	○

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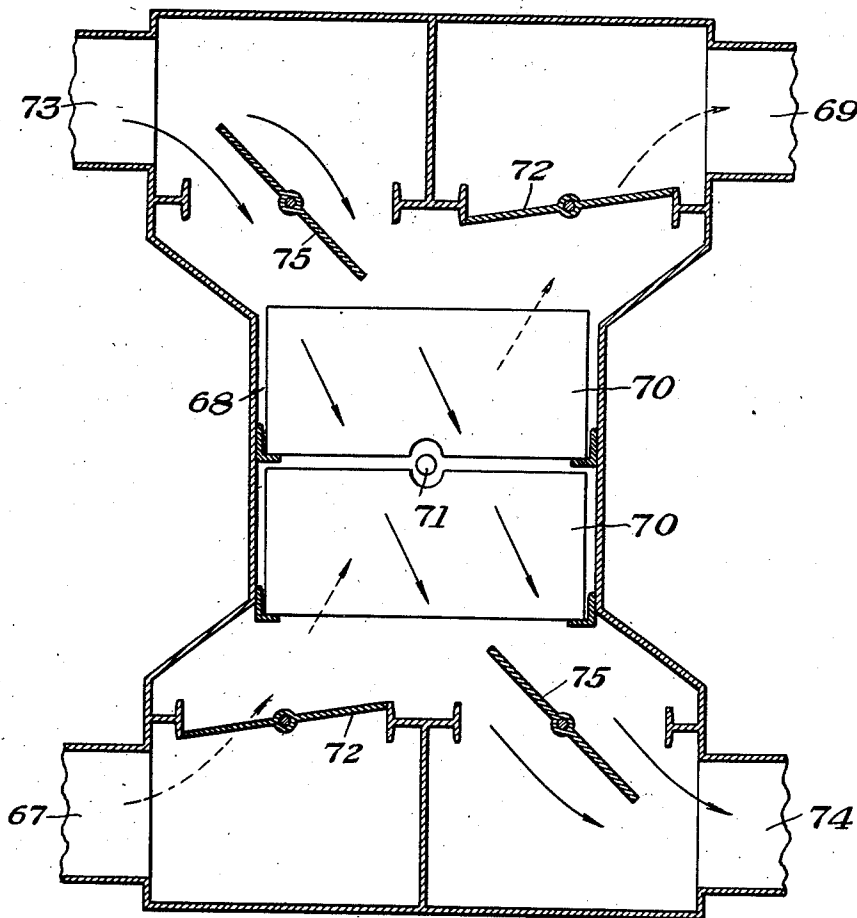
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Fig. 15.



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UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

Application filed January 26, 1928. Serial No. 249,547.

This invention relates to heat exchangers, and particularly to methods and apparatus for heating air and gases.

In my prior Patent 1,543,909, dated June 30th, 1925, there is described and claimed a heat exchanger comprising a plurality of chambers through which heating gases and gas to be heated are alternately passed, the flow of gases through the chambers being controlled by valves.

The present invention relates to a heater of the general type shown in said Patent 1,543,909, but provides a number of improved features of construction and operation.

These heaters have numerous industrial applications, such as preheating of air for combustion by utilizing the heat of the furnace gases. The hot gases are first caused to flow through a chamber for a desired period, then the gas flow is shut off and air to be heated is passed through the chamber. A plurality of chambers are employed and they are operated out of phase so as to give a substantially continuous supply of heated air.

The heat exchanger is preferably arranged so that the heating gases flow therethrough in one direction and the gas to be heated passes therethrough, in the opposite direction. In order to give the chambers the desired heat capacity they are provided with heat retaining bodies such as metal plates, rods or wires. In operation these heat retaining bodies tend to warp under the high temperatures to which they are subjected. This difficulty can be overcome by making the heat retaining bodies out of materials such as alloy steels, which are particularly adapted to withstand high temperature, but this can only be done at considerably increased expense. I provide a series of heat retaining bodies made of materials capable of withstanding different temperatures and arrange these bodies in the chambers in such manner that the bodies which are most resistant to high temperature are in the hottest parts of the chamber. With this arrangement a material saving in cost may be effected, and at the same time all of the heat retaining bodies are capable of

withstanding the temperatures to which they will be exposed in normal operation.

The valves and their seats are also subject to warping or distortion under the temperatures encountered, and I therefore provide valves and seats which are capable of withstanding the temperatures developed in operation.

The plates, rods or wires provided in the chambers are preferably grouped into heating elements which may be handled as a unit. These elements preferably comprise spaced apart plates or rods so as to permit of the ready passage of gas or air therebetween.

In operation the heating elements frequently become so coated with soot or dirt that the efficiency of the heat exchanger is materially reduced. In order to overcome this I provide cleaning means for the heating elements. Preferably this cleaning means comprises a blower arranged between the plates or wires and adapted to direct jets of steam or other cleaning gas over the surface thereof. There will usually be so many plates that it would not be feasible to provide a sufficient number of steam nozzles to discharge between each pair of plates at one time. I therefore provide a conduit having nozzles formed therein, together with means for shifting the axial position of the conduit and at the same time rotating the same so that all the surfaces of the heat exchanging elements are subjected to the action of the steam or other cleaning fluid.

In my patent above referred to, the valves are operated by crank means and their motion is therefore on the order of a simple harmonic motion. I have found that it is desirable to modify this motion of the valves in order to secure the best results. I preferably employ cam means for operating the valves and so control the movement of the valves that a substantially uniform flow of gas or air is obtained. Considering as an example the air valves for any particular chamber, the valve operating means will be effective first for opening the valves over a definite time period, then holding them open for a desired period, then effecting a closing movement over a desired time period, after

which the valve remains closed during that portion of the cycle in which heating gases are passed through the chamber. In employing a heater having a plurality of chambers the valves are so timed that when the air valves for one chamber are opening the air valves for another chamber are closing. The amount of opening of a valve at any given time relative to maximum opening is not in direct ratio to the amount of air which may pass through the valve relative to the amount which may pass through the valve at maximum opening. A certain loss of head is always encountered in a valve and my improved valve opening means compensates for these head or draft losses, so that the quantity of air or gas flowing through the apparatus is substantially constant at all times.

Particularly in boiler installations the available draft for the heating gases is relatively low. In order to take care of this condition I provide for passing the heating gases through the chambers at a lower velocity and therefore use a smaller draft loss than the velocity at which the gas to be heated is passed through the exchanger. This may be readily accomplished by passing the heating gases through more chambers than are being then employed for the heating of the air.

I further provide for operating the various chambers forming the heat exchanger in such sequence that uniform distribution of the waste gases is obtained, and fluctuations in the flow of gas or air are reduced or eliminated. Provision is also made for separating the chambers from one another in such way that material pressure differences may exist between adjacent chambers without contamination of the gases in one chamber by the gases in an adjacent chamber.

In the accompanying drawings illustrating the present preferred embodiment of my invention, and certain modifications thereof

Figure 1 is a transverse section through one form of heat exchanger embodying certain features of my invention,

Figure 2 is a transverse section on the line II—II of Figure 1,

Figure 3 is a view of one of the cams employed for actuating the valves,

Figure 4 is a diagram showing the motions of the valves for the heat exchanger of Figures 1 and 2,

Figure 5 is a side elevation of a heat retaining member employed in the heat exchanger and made of metal plates,

Figure 6 is an edge view thereof,

Figure 7 is a transverse section through a modified form of heating unit employing rods or wires,

Figure 8 is a section through the heating element of Figure 7 and taken at right angles to the section of Figure 7,

Figure 9 is a view corresponding generally

to Figure 2 but showing a modified form of heat exchanger,

Figure 10 is a sectional view to enlarged scale of the cleaning device for the heat retaining members,

Figure 11 is a diagrammatic view showing the arrangement of chambers and valves in a heater comprising four chambers,

Figure 12 is a diagram showing the operation of the valves in a heater of the type indicated in Figure 11,

Figure 13 is a view corresponding to Figure 11 but showing a heater having six chambers,

Figure 14 is a valve diagram for the heater of Figure 13, and

Figure 15 is a transverse section largely diagrammatic through a modified form of heat exchanger employing butterfly valves.

Figures 1 and 2 illustrate a heater comprising three chambers. It comprises an outer casing 2 built up of steel plates and lined with masonry construction 3. A flue 4 extends beneath the bottom of the heat exchanger and carries heating gases thereto. These gases may be stack gases from a boiler furnace installation or from a heating furnace. Uptakes 5 extend from the gas passage 4 to a side extension 6 of each of the chambers 7 comprising the device. Valve seats 8 for mushroom valves 9 are provided at the top of each up-take 5 to control the ingress of hot waste gases to the chambers 7. Each valve 9 is loosely connected through a cross pin 10 to a vertically extending valve operating rod 11. This rod extends through an opening formed in a top wall 12 for each chamber 7, and having a valve seat 13 formed therein. A mushroom valve 14 is loosely carried on the valve rod 11 by a cross pin 15. The valve 14 controls the egress of the waste gases from the chamber 7. When the valve rod 11 is lifted the valves 9 and 14 are both lifted from their seats so that hot waste gases may pass through the chamber 7 and discharge into a conduit 16 running along the top of the heat exchanger.

A conduit 17 is provided at the top of the chamber alongside the conduit 16. Cold air or other gas to be heated is supplied through this conduit. The division wall 12 forms the bottom of the conduit 17 as well as the bottom of the conduit 16 and is provided with openings having their edges formed into valve seats 18, one for each chamber 7. A valve rod 19 extends downwardly through each of the openings and carries a mushroom valve 20 which is loosely connected to the valve rod through a cross pin 21. At its bottom end each rod 19 carries a mushroom valve 22 which is loosely connected to the rod through a cross pin 23. Each valve 22 has a seat 24 formed at the top of an up-take 25 communicating with a passage 26 running parallel to the passage 4. When the rod 19

is in raised position the valves 20 and 22 are open, thus permitting the flow of air or other gas to be heated from the conduit 17 through the chamber 7 and thence to the passage 26.

5 The rods 11 and 19 extend through openings formed in the top wall 27 of the heat exchanger, which top wall 27 partly defines the conduits 16 and 17. At their upper ends the rods are provided with nuts 28 providing an
10 adjustable shoulder for valve operating forks 29. The forks 29 embrace the valve rods 11 and 19 and are formed integral with rocker arms 30. The rocker arms 30 are provided at each end with oppositely extending
15 pins 31 adapted to seat in brackets 32. Each rocker arm 30 is provided with spaced upstanding portions 33 carrying follower rollers 34 and 34' adapted to engage a cam 35 secured to a shaft 36.

20 The tendency of the rocker arm 30 is to move to such a position that the pins 31 engage each of the brackets 32 with the rocker arm in a horizontal position. As the shaft rotates, the cam 35 engages one of the fol-
25 lower rollers, say the roller 34, and forces it to the right as viewed in Figure 1, and causing the valve rod 11 to lower and seat the valves 9 and 14 while causing the valve rod 19 to rise and lift the valves 20 and 22 away from their
30 seats. Upon continued rotation of the shaft 36 the rocker arm 30 is restored to its horizontal position, after which the cam engages the roller 34' to effect closing of the valves 20 and 22 and opening of the valves 9 and 14.
35 The shaft is rotated at uniform velocity so that the movement of the valves takes place in regular sequence, and the length of time the several valves remain open or closed is determined by the shape of the cam 35. This
40 feature is more fully described hereinafter.

The cross pins 10, 15, 21 and 23 extend through elongated openings in the necks of the corresponding valves, as best shown in Figure 2. This loose connection ensures
45 proper seating of the valves and provides a limited degree of lost motion in the connection between the valves and their operating rods, as set out in my prior patent above referred to.

50 The shaft 36 is mounted in pedestal bearings 37 and is driven by a motor 38 through a speed reducer 39. The cams 35 for the several chambers are keyed to the shaft and occupy such relative angular positions with
55 respect to the shaft that the several chambers are operated out of phase with one another.

Figure 4 is a diagram showing the operation of the valves for each chamber. The
60 solid line g_1 represents the motion of the gas valves for chamber No. 1 in the heat exchanger, and the line a_1 represents the movement of the air valves for that chamber. The lines g_2 and a_2 , g_3 and a_3 represent the corresponding movements of the gas and air

valves, respectively, for chambers 2 and 3 of the exchanger. Horizontal distances on the chart represent degrees of rotation in one revolution of the cam shaft 36. Considering
70 first the lines g_1 and a_1 , it will be seen that starting at zero degrees of rotation, as shown on the chart, the gas valve is raised from its seat to full open position during 60° of revolution, then remains wide open for 60° of
75 revolution and is then closed through 60° of revolution. During this total of 180° of revolution the air valves remain closed. During the next 180° of revolution the gas valves for chamber 1 remain closed while the air
80 valves are given 60° of opening movement, then 60° of dwell in the open position, and then 60° of closing movement. The movement of the gas and air valves for the chambers 2 and 3 is the same as for chamber 1 except that they are out of time, the cam for
85 chamber 2 being so positioned that the above described sequence of valve movements is 120° later than for chamber 1, and the cam for chamber 3 being so positioned on the shaft that the sequence of valve movements is 240°
90 later than for chamber 1.

It will be seen that with this arrangement a substantially continuous flow through the heat exchanger of heating gases and gas to be heated is obtained. Taking for example the
95 condition represented by the line X—X on Figure 4, it will be seen that the gas valve for chamber 1 is fully open and that the air valves for chambers 2 and 3 are partly opened, the
100 air valves for chamber 2 being in process of closing and the air valves for chamber 3 being in process of opening.

As above pointed out, variation in flow through the apparatus may arise from the
105 fact that the resistance to flow through a valve is not in exact proportion to the degree of opening of the valve, and further, because the resistance to flow through the chambers will vary with the velocity of the gases there-
110 through. In other words, if we assume the condition represented by the line X—X, it will be seen that chambers 2 and 3 are operating in parallel and therefore the velocity of the air therethrough will be lower than the
115 velocity of the air when it is passing through one chamber only.

Figure 4 shows chain lines 40 representing the degree of opening of the valves at any
120 time if they were moved with uniform velocity from closed to open position, and vice-versa. It will be noted that the lines g_1 , g_2 , g_3 and a_1 , a_2 , a_3 , depart materially from these
125 straight lines 40. This departure is controlled by the shape of the cams 35 and is such that the total resistance to flow of gas or air through the apparatus is maintained
substantially constant at all times.

Referring again to the condition obtaining at a time as indicated by the line X—X on
130 Figure 4, w_2 and w_3 in that figure represent

the amount of valve opening of the air valves for chambers 2 and 3, respectively. The line X—X is 30° removed from the 60° abscissa and therefore represents the condition which obtains when half of the time allotted for opening or closing the air valves in chambers 2 and 3 has elapsed. It will be noted that at this time, instead of the valves being 50% open, they are each about 40% open, so that their total valve opening does not correspond to 100% of a fully open valve, but only to about 80% of a fully open valve, thus compensating for the decreased resistance occasioned by temporarily operating the chambers 2 and 3 in parallel.

Figure 3 shows one of the operating cams in detail. Chain lines 40' are drawn on Figure 3 to illustrate the shape of a cam for operating the valves in such a way as to follow the straight lines 40 on the diagram Figure 4 and thus more clearly show the manner in which the cam shape is modified to give the modified valve action above described.

Figure 4 shows the movements of the gas and air valves beginning and terminating at exact 60° intervals, but it will be understood that in operation the lost motion provided by the elongated openings in the necks of the several valves modifies the valve movement to the extent of causing a slight dwell at the end of the stroke so that there is no danger of admixing gas and air. By making the elongated openings in the necks of the valves of different length, and thus providing different degrees of lost motion for the several valves, the valve movement may be further modified so that any residual gases left in a chamber when the inlet valve for waste gases is closed may be swept out before the chamber is actually used for air heating.

Referring to Figures 1 and 2, the valve 14 is shown as having an elongated opening 41 in its neck, of such length that the valve 14 seats before the valve 9. The valve 22 is made similar to the valve 14—that is to say, it is provided with an unusually long opening in its neck so that it seats before the valve 20 and opens after the valve 20. The rollers 34 and 34' on the follower 30 are so placed that the movements of the valve rods 11 and 19 are timed to cause opening of the valve 20 before the valve 9 is fully closed. It follows that for a short period in the operation of each chamber the valves 14 and 22 will be closed while the valves 20 and 9 will be open. The cold air to be heated is usually supplied by a blower and is under considerably more head than the stack gases which are used to heat the apparatus. Due to this difference in pressure cold air will flow past the valve 20 through the chamber 7 and past the valve 9 to the passage 4, thus expelling any waste gases contained in the

chamber. This method eliminates contamination of the air to be heated with only the expense of a slight loss of heat. This method will not ordinarily be needed in combustion work, but where a high degree of purity for the heated gas is desired, it provides a simple and effective method of purging the chambers.

The heat capacity of the chambers 7 is obtained by banks of heating elements H_1 , H_2 , and H_3 . Since the waste gases enter at the bottom of the chamber and leave at the top, the lowest bank of heating elements will be exposed to the highest temperature and the top bank will be exposed to the lowest temperature. Each section will, of course, be somewhat hotter at its lower side than at its upper side. By arranging the heating elements in banks it is possible to employ materials which will withstand the temperatures encountered, and at the same time maintain the cost of the heater at a minimum. For example, the bank H_1 may be made of a high heat resisting material, for instance, one containing 25% to 30% chromium. This material will successfully withstand temperatures as high as 2200° F. The middle bank H_2 may be made of a less expensive material, say a steel containing 12 to 15% chromium. This material will successfully withstand temperatures up to about 1500° F. The upper bank H_3 may be made of ordinary steels which are capable of withstanding temperatures up to about 1000° F. Twisting or warping of the heating elements is thus avoided, and at the same time the cost of the heat exchanger is maintained relatively low.

The lower valves 9 and 22 are made of high chromium steel containing, say, 25% to 30% chromium, and the valve seats 8 and 24 are also made of this material. The valve seat 8 is shown in Figure 1 as being of water cooled construction. This valve seat is subjected to higher temperatures than any other in the apparatus. The valves 14 and 20 and their seats are not subjected to such high temperatures as the bottom valves, and therefore may be made of less expensive material.

When high temperatures are encountered the manner of supporting the heating elements becomes particularly important if warping and sticking of the elements is to be avoided. Figure 1 shows shelves or brackets 42 arranged to engage notches 43 formed in the heating elements H_1 and H_2 . The heating elements H_3 , which are not subjected to such high temperatures, are supported on bars 44 which rest on the top of the heating elements H_2 .

The heating elements are rendered accessible for cleaning or removal by the provision of side doors 45 for the chambers 7. The brick work 46 inside the door is made removable so that the heating elements may be readily laid open to view for inspection or

cleaning. One advantage of hanging the plates is that they can be rocked or shaken to remove dust deposits.

If high pressure gases are passed through the apparatus it is not sufficient to merely provide a brick or masonry wall between the several chambers. Such walls cannot withstand more than a few inches of pressure difference without serious leakage. Figure 2 shows a division wall comprising spaced apart plates 47 having brick lining 48. Air is free to circulate between the plates 47 so as to cool them in a certain amount. A heater of this type is capable of withstanding high pressures and temperatures.

Figures 5 and 6 show a preferred form of heating element made up of steel plates 48. These plates are fastened together by bolts 49 so as to form bundles or units which may be readily handled. Projecting bosses 50 are struck up from certain of the plates in opposite directions so as to hold the plates spaced apart, and thus permit of free passage of gases, even if the plates tend to warp. Separation is further insured by the provision of spacers 51 for the bolts 49.

Figures 7 and 8 show a modified heating element comprising an outer case 52 made of metal plates, and having cross bolts 53 adjacent its upper end. Metal rods or wires, bent to hairpin shape, are supported on the cross bolts 53. Additional cross bolts 54 running parallel to the bolts 53, and bolts 55 running at right angles thereto, are provided to keep the rods or wires separated, thus insuring that their relative position will not be materially disturbed even in the event of warping. Whether plates or rods are employed it is desirable to have a certain degree of looseness in the sections to facilitate cleaning.

Cleaning of the heat exchanging elements is of importance if high efficiency is to be obtained. As shown in Figures 1 and 2, the provision of the side opening 45 permits of access to the banks of heating elements so that they can be cleaned, but it may be desirable to build cleaning means into the apparatus. Such a means is shown in Figures 9 and 10 and comprises steam pipes 56 arranged between banks of heating elements, and provided with nozzles 57. The inner ends of the pipes 56 are closed off but their outer ends open into valve casings 58 secured to the shell of the heater. A steam pipe 59 leads into each shell 58, the passage of steam being controlled by a valve 60. When the valve 60 is opened, steam passes through the pipe 56 and issues at high velocity from the nozzles 57 thus effectively cleaning away any accumulated dust or dirt which may lie in the path of the steam jets.

A stem 61 is threaded in the valve casing 58 and extends outwardly through a packing gland 62 to receive a hand wheel 63. The

inner end of the stem 61 is formed into a spider 64 terminating in a collar 65 into which the pipe 56 is threaded. By turning the hand wheel 63 the pipe 56 is correspondingly turned so that the jets issuing from the nozzles 57 also rotate and sweep over the entire area of the plates in their path. It would be difficult or impossible to provide sufficient nozzles to simultaneously direct steam jets between all of the plates, but the provision of the threaded stem 61 permits of using a materially smaller number of such nozzles. As the hand wheel 63 is rotated, the pipe 56 is not only rotated but is also moved axially so that the nozzles 57 follow a helical path and are effective for directing the steam jets between all of the plates.

Figure 9 shows a low temperature heater comprising four chambers 7_a, 7_b, 7_c, and 7_d. This heater is not lined with refractory material as there is no necessity for this at the temperature at which the heater works. The heater is capable of withstanding high pressure, there being no communication between the chambers except through the valves and through the openings in the division walls between the chambers 7_a and 7_c and between the chambers 7_b and 7_d through which the pipes 56 pass. These openings may be made closely fitting so that the leakage is negligible.

Figure 11 shows the heater of Figure 9 in diagrammatic plan and Figure 12 is a valve diagram corresponding to Figure 4 and showing the operation of the valves.

Considering the condition obtaining between zero and 45° of revolution of the cam shaft, it will be seen that gas passes through chambers 7_a, 7_c and 7_d the gas valves for chamber 7_a being in process of opening, those of chamber 7_c being in the process of closing and those of chamber 7_d being in process of being fully opened. Between 45° and 90° of revolution of the cam shaft, the gas valves for chambers 7_a and 7_b remain fully open while the gas valves for chamber 7_c become fully closed. During this portion of the cycle the air valves for chamber 7_b are in process of closing and for chamber 7_c are in process of opening. Between 90° and 135° of revolution of the cam shaft the gas valves for chamber 7_a remain open, those for chamber 7_b are in process of opening, those for chamber 7_c remain closed and those for chamber 7_d are in process of closing. The air valves for chambers 7_a, 7_b and 7_d are entirely closed while those for chamber 7_c are fully open. Between 135° and 180° of revolution of the cam shaft the gas valves for chambers 7_a and 7_b remain fully open while the air valves for chamber 7_c are in process of closing, and the air valves for chamber 7_d are in process of opening. The cams for operating the valves are so shaped that during a total of 225° of revolution of the cam shaft the gas valves

for any chamber are partly or entirely open and the air valves are closed, while for 135° of revolution the gas valves are closed and the air valves are partly or fully open. The
 5 air valves stay at full opening for 45° of revolution while the gas valves remain at full opening for 135° of revolution. There is thus provided a materially longer period for the
 10 passage of gas than for the passage of air, and the periods of operation for the valves of the several chambers overlap to such an extent that there is always the equivalent of one open valve for air and two open valves for gas. As shown by solid lines in Figure 12,
 15 the rate of opening of the valves is modified from "straight line" opening so as to compensate for the variation in resistance offered to gaseous flow. This arrangement is particularly useful where low drafts for the
 20 waste gases are available. There is always twice as much area available for the flow of heating gases as for gas to be heated. It is therefore possible to pass a greater quantity of heating gases through the exchanger
 25 with less loss of draft than for air.

It will be noted from Figures 9 and 11 that going from one end of the heat exchanger to the other the chambers are arranged in the order 7_a, 7_c, 7_b and 7_d. It will be seen that
 30 with this arrangement the flow of gas at any period is substantially equally divided between the chambers 7_a and 7_c at one end of the exchanger and the chambers 7_b and 7_d at the other end thereof. A corresponding distribution of air to the several chambers is
 35 also secured at any time. This arrangement is of value because, as shown in Figure 11, the air and gases pass in from the sides of the apparatus. The uniform distribution of
 40 gases is of importance in various installations, as for example, where the heat exchanger is applied to a boiler furnace in such a way that the waste gases flow substantially directly from the furnace into the exchanger.

Figure 13 shows diagrammatically a heater employing six chambers numbered respectively 66_a, 66_b, 66_c, 66_d, 66_e, and 66_f.

As shown by the diagram Figure 14, all of the valves in the heater of Figure 13 open and close during a 30° turn of the cam shaft.
 50 The gas valves remain fully open during 150° of revolution and the air valves remain fully open during 90° of revolution. In all, during 210° of revolution of the cycle the gas valves are open and during 150° of revolution of cycle the air valves are open. As a result of this there is at all times an opening
 55 corresponding to three valves for waste gases and two valves for air. This arrangement, like that of the heater shown in Figures 9 and 11, is particularly useful for furnace installations where the waste gases are always greater in volume than the amount of air required for combustion. The arrangement
 60 of chambers in the heater of Figure 13 is

66_a, 66_a, 66_b, 66_c, 66_c, and 66_f. With this arrangement one third of the waste gases always passes up through the left third of the heater, one third through the middle third of the heater and one third through the
 70 right third of the heater. The distribution of air is the same.

Figure 15 shows a modified form of heater employing butterfly valves instead of mushroom valves. Hot waste gas enters at 67,
 75 passes through the heating chamber 68 and leaves through a passage 69. The chamber 68 contains heat retaining elements 70 and a cleaner 71. The flow of heating gases is controlled by valves 72 which are arranged to
 80 be operated through any desired valve linkage. Gases to be heated enter at 73, pass through the chamber 68 and are taken off at 74. The flow of the gas to be heated is controlled by butterfly valves 75, which are also
 85 operated together in any desired way. It will be understood that with a heater of the type shown in Figure 15, the valves may be actuated so as to purge the chamber between different phases of the cycle and that a plu-
 90 rality of chambers may be employed so as to give the desired relative resistance to flow of gas and air, and the desired distribution of gases along the exchanger. An advantage of the apparatus shown in Figure 15 is that
 95 the heating gases enter at the lower left hand corner and leave at the upper right hand corner, while the gas to be heated enters at the upper left hand corner and leaves at the lower right hand corner. This gives good
 100 distribution of air and waste gases across the heating chamber 68 even though the height be relatively small relative to the width. Short circuiting of flow in the chamber is thus prevented and high volumetric efficiency
 105 is obtained.

While I have illustrated and described the preferred form of my invention, it will be understood that it is not limited to this form as it may be otherwise embodied or practiced
 110 within the scope of the following claims:—

I claim:—

1. A heat exchanger comprising a plurality of chambers adapted for the intermittent passage of gas therethrough, a valve for
 115 each chamber, and means for operating the valves out of phase with one another and being so constructed and arranged that each valve is alternately opened and closed and at such relative rates that the total resistance
 120 to gas flow offered by all the valves is substantially constant.

2. A heat exchanger comprising a plurality of chambers adapted for the intermittent passage of gas therethrough, a valve for each
 125 chamber, and cam means for operating the valves out of phase with one another and being so constructed and arranged that each valve is alternately opened and closed and at such relative rates that the total resistance
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to gas flow offered by all the valves is substantially constant.

3. A heat exchanger comprising a plurality of chambers adapted for the intermittent passage of a gas therethrough, a valve for each chamber, and means for operating the valves out of phase with one another and being so constructed and arranged that each valve is alternately opened and closed and at such rates that the rate of valve motion during that half of its stroke when the valve is closest to its seat is relatively slow, as compared with its movement during the other half of its stroke.

4. The method of operating a heat exchanger having a plurality of chambers adapted for the intermittent passage of a gas therethrough, and having valves for controlling such passage, which includes operating the valves for different chambers out of phase with one another and opening and closing the valves at such relative rates that the total resistance to gas flow offered by the several chambers and their valves is substantially constant.

5. The method of operating a heat exchanger having a plurality of chambers with a heat capacity, which includes alternately passing heating gases and gas to be heated through the several chambers, operating the chambers out of phase with one another to as to give a substantially constant supply of gas to be heated, and passing one of said gases through a chamber for a longer period than the period during which the other of said gases is passed therethrough.

6. A heat exchanger comprising a plurality of heat exchanging chambers arranged side by side, and a division wall for the chambers comprising refractory material having a metal plate therein.

7. A heat exchanger comprising a plurality of chambers arranged side by side, the adjacent walls of the heat exchanging chambers being made of refractory material, and a metal plate between the walls so as to prevent the passage of gases through said walls.

8. A heat exchanger comprising a chamber, means for supplying hot gas and gas to be heated therethrough, and independently suspended banks of plates in the path of the gases, the plates having notches adjacent their upper edges and supports in the chamber engaging the notches so as to hold the plates in suspension.

9. A heat exchanger comprising a chamber, means for supplying hot gas and gas to be heated therethrough, and independently suspended banks of plates in the path of the gases, the plates having notches adjacent their upper edges and supports in the chamber engaging the notches so as to hold the plates in suspension, different plates being of different heat resisting quality, the plates

being arranged in the path of the hot gases in decreasing order of heat resisting quality.

In testimony whereof I have hereunto set my hand.

WALDEMAR DYRSSEN.

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CERTIFICATE OF CORRECTION.

Patent No. 1,835,148.

Granted December 8, 1931, to

WALDEMAR DYRSSEN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, line 110, for "7b" read "7_d"; page 7, line 32, claim 5, for the word "to" first occurrence read so; same page, line 44, claim 7, strike out the words "heat exchanging" and insert the same before "chambers in line 43, of same claim; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of February, A. D. 1932.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.