# United States Patent [19]

**Nakanishi**

[11] **3,770,050**

[45] **Nov. 6, 1973**


[54] **REVERSING HEAT EXCHANGER UNIT**


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[22] Filed: **July 15, 1971**

[21] Appl. No.: **162,835**

[52] **U.S. Cl.** .......... **165/97,** 62/13, 62/15, 137/309, 137/512, 137/595

[51] **Int. Cl.** .......... **F28f 27/02**

[58] **Field of Search** .......... 165/97; 137/309, 137/512, 595; 62/13, 14, 15; 210/277, 278, 340



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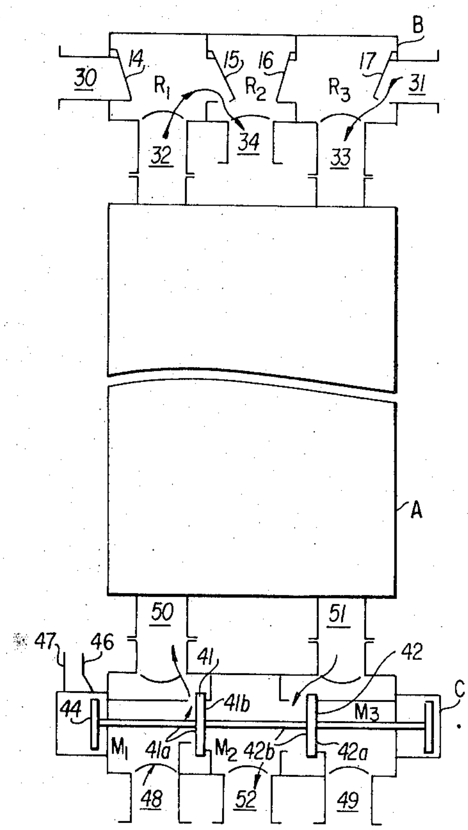
[57] **ABSTRACT**

A reversing heat exchanger system not divided into the usual blocks and having change-over valves and check valves provided in each reversing heat exchanger unit to unify them and thereby to prevent the loss of raw air upon exchange of raw air and waste gas paths, to prevent abrupt pressure changes, to enable stable operation of a rectification system, and to standardize the change-over valves and check valves in order to facilitate easy design and manufacturing of the reversing heat exchanger system.


**5 Claims, 10 Drawing Figures**



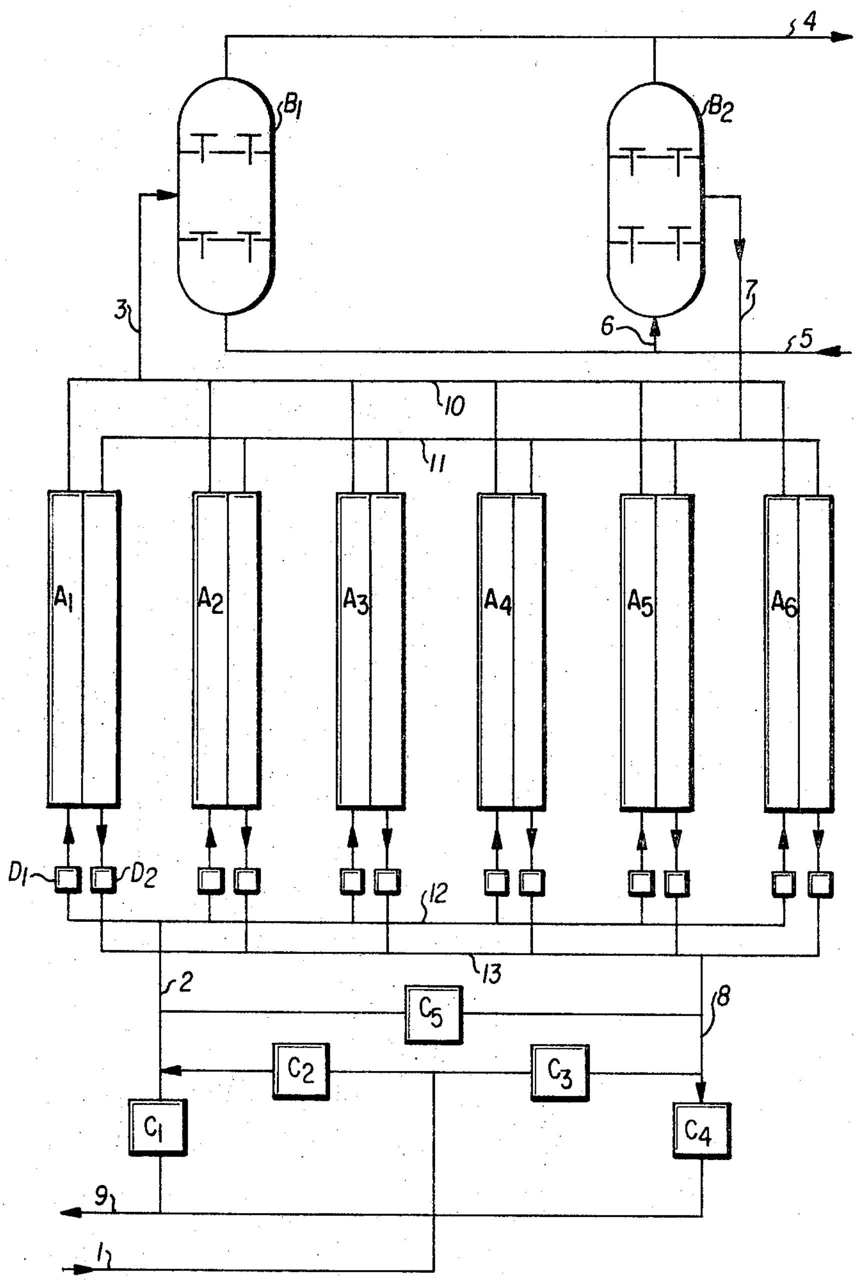



FIG.1

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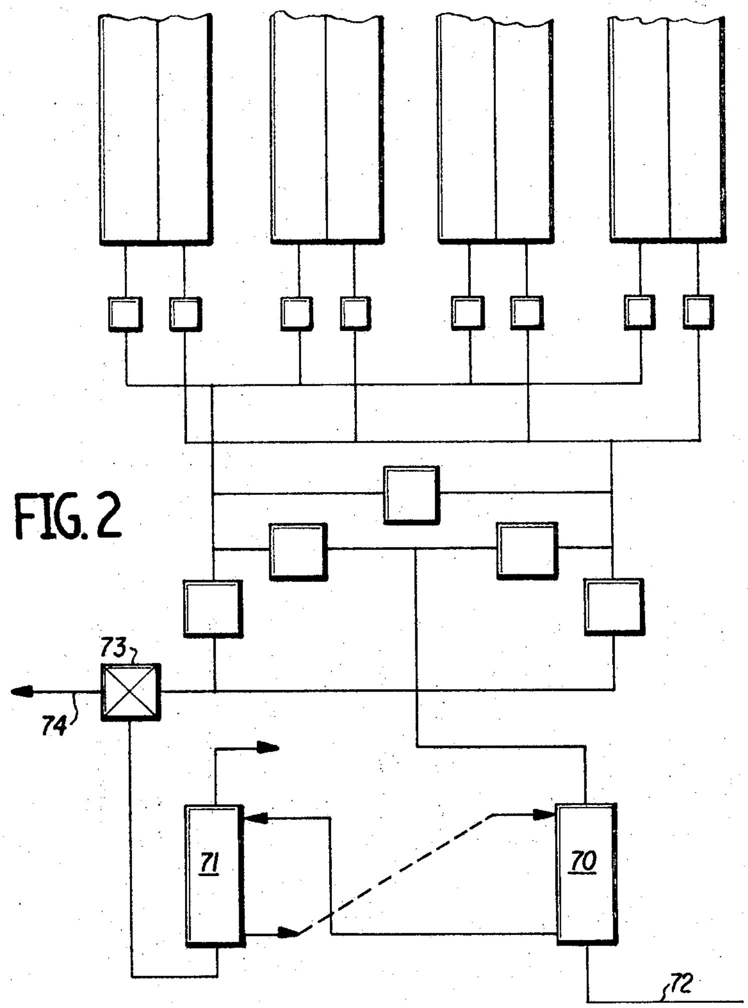
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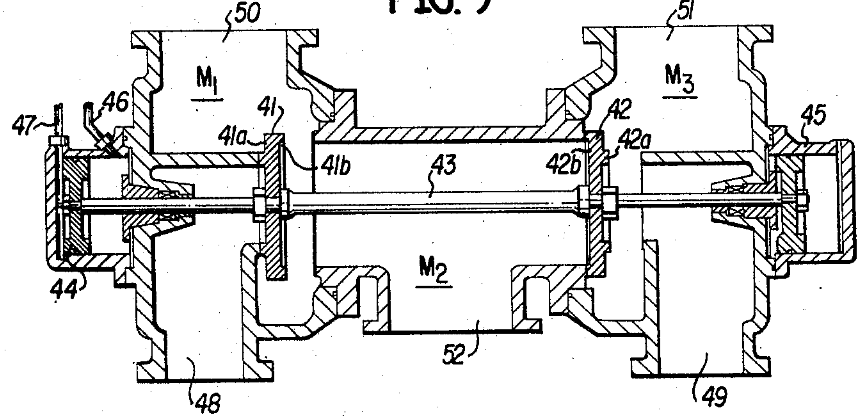
FIG. 2

FIG. 3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M1
M3
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41b
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42a
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M2
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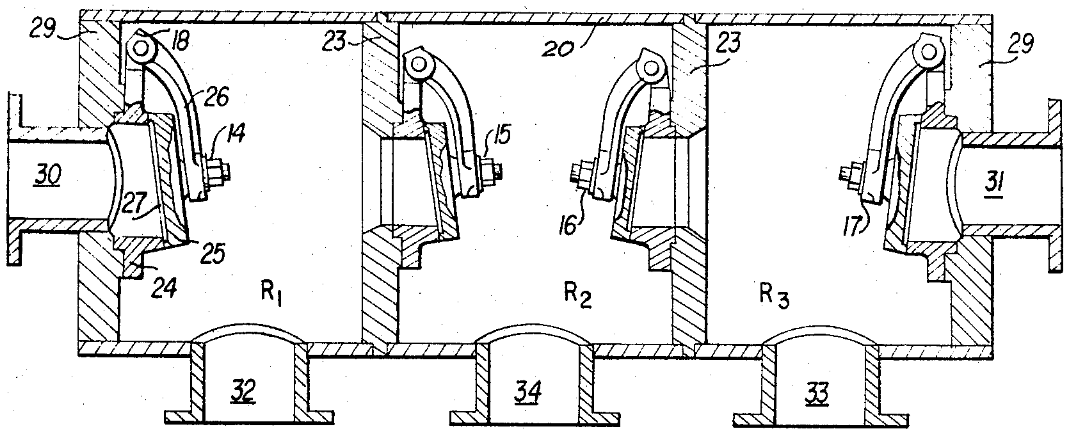
29
18
23
20
23
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26
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31
25
24
R1
R2
R3
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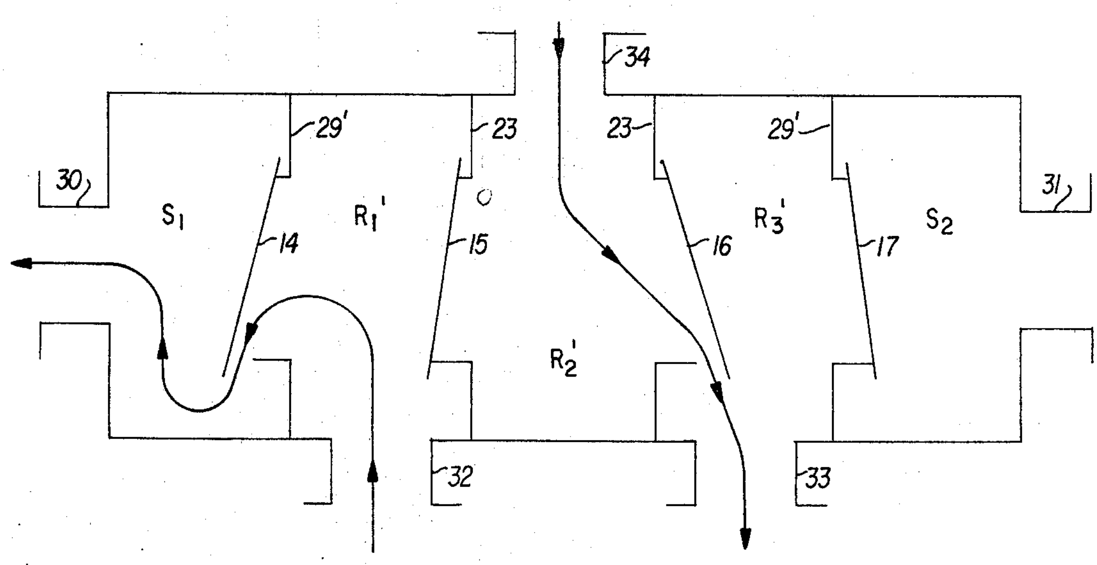
34
33

FIG. 4

FIG. 5


34
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R3'
S2
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R2'
32
33

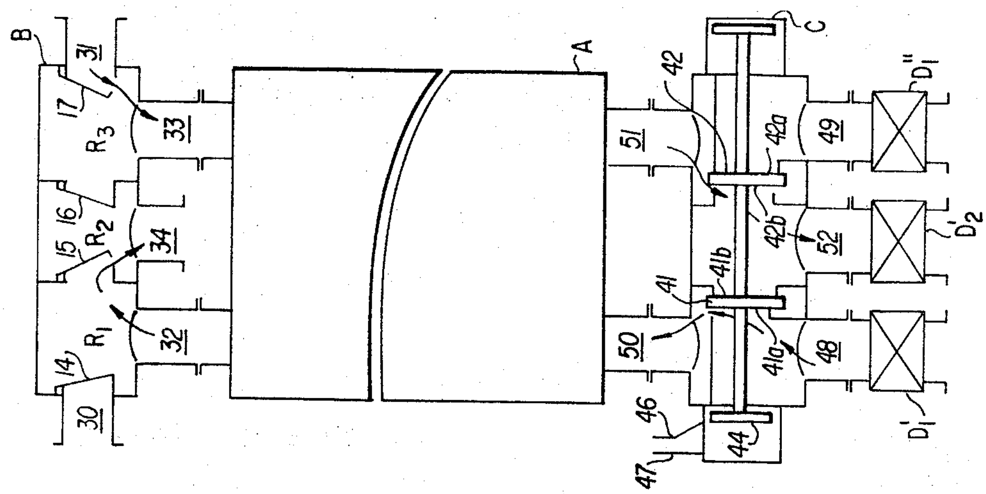


FIG. 8

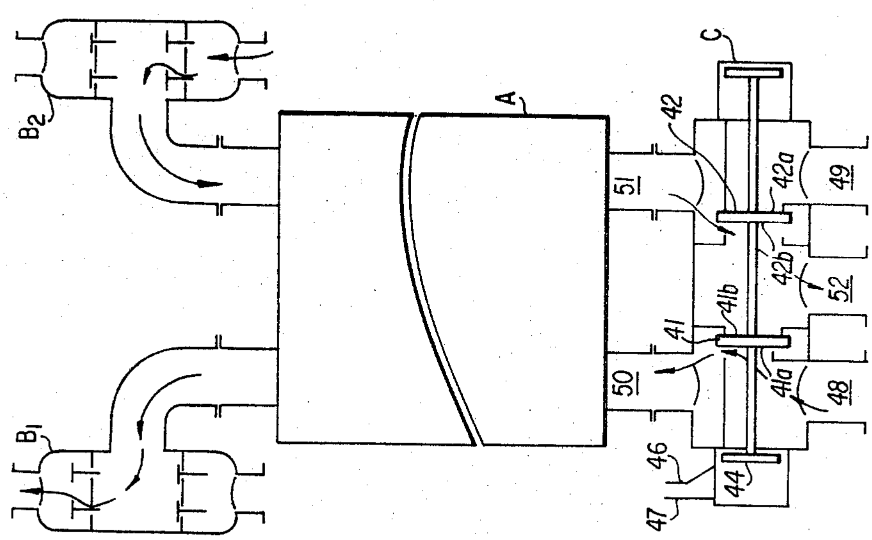


FIG. 7

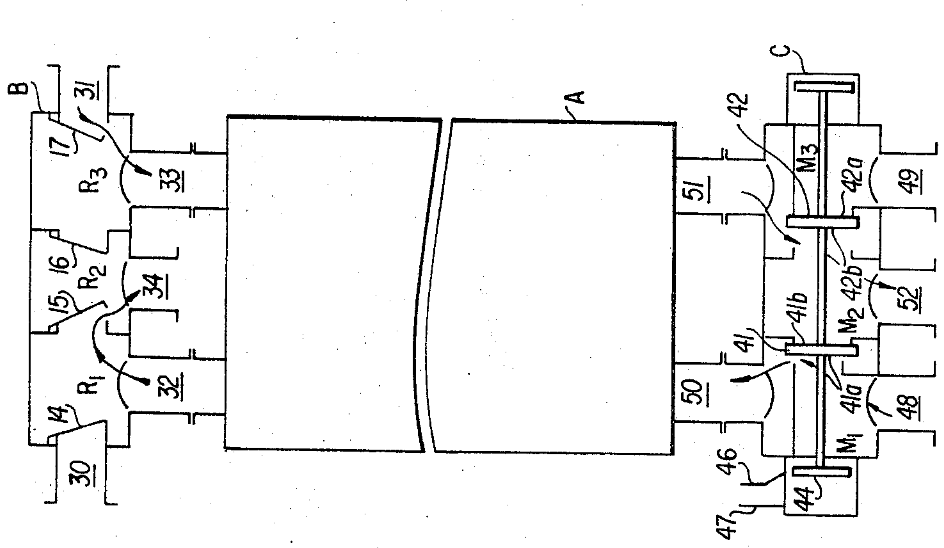


FIG. 6

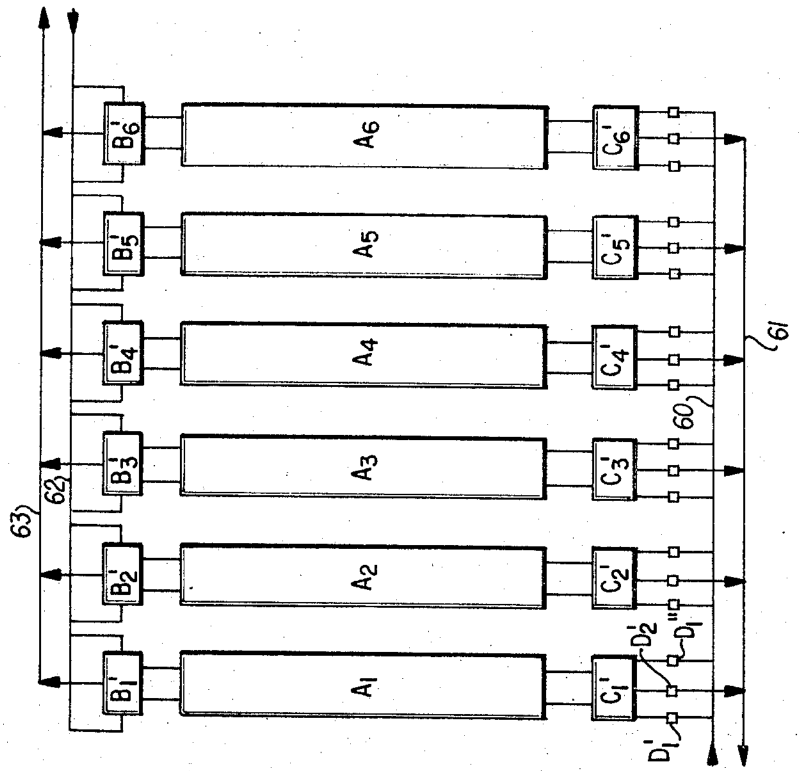
A1
A2
A3
A4
A5
A6
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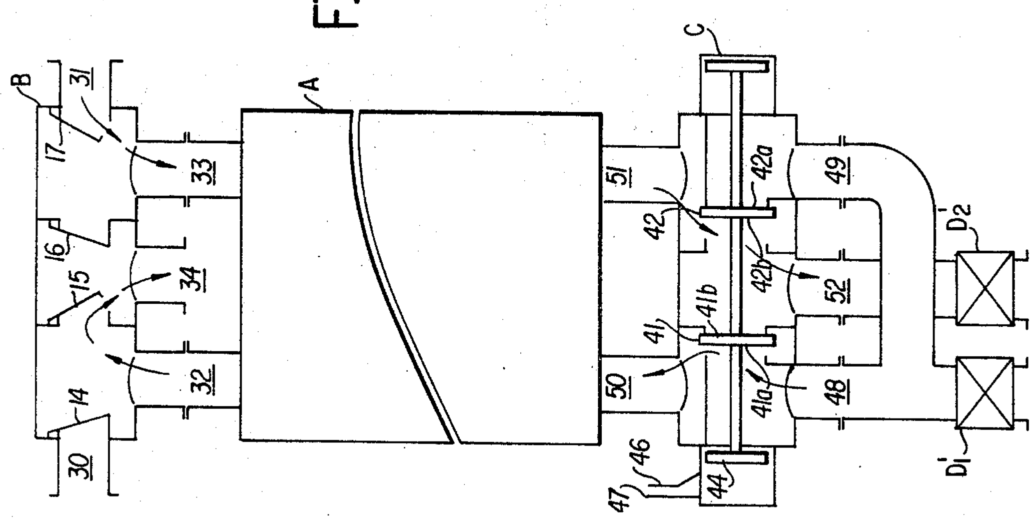
FIG. 10


A
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42a
42b
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FIG. 9

## REVERSING HEAT EXCHANGER UNIT

### BACKGROUND OF THE INVENTION

This invention relates generally to reversing heat exchanger units used in low temperature air separators and more particularly to a unified reversing heat exchanger characterized by the provision of a novel arrangement of change-over valves and check valves in a conventional reversing heat exchanger.

Heretofore, standardization of conventional air separators has been very difficult because the separators usually have several blocks of heat exchangers, each block in turn having change-over valves and check valves, and yet the number of blocks and the number of heat exchangers in any one block are optionally determined by the capacity of the separator, whereby the size and number of the change-over valves and check valves depend variably upon the design conditions thereof so that not only the capacity of the change-over valves and the check valves, but the related components, such as piping, cold box, and the like must be designed into every separator. Since the capacity of a single heat exchanger is substantially constant for the convenience of manufacturing, the number of the reversing heat exchanger units is determined by the desired capacity of the air separator, but since the number of heat exchangers in one block and the number of blocks are contrary to each other, it is necessary to enlarge the capacity of the check valves and the diameter of the ports of the change-over valves, when the number of heat exchangers in one block is increased so that the treating capacity of the block becomes larger, in order to decrease the total number of the change-over valves and check valves. In order to decrease the diameter of the port of the change-over valves and the capacity of the check valves, it is necessary to increase the number of the blocks and to increase the total number of the change-over valves and check valves. Accordingly, as the sizes of the change-over valves and check valves are different depending upon various design conditions, it is difficult to unify the change-over valves and check valves for such heat exchanger systems.

The exchange of raw air and waste gas from their respective paths is conducted by a plurality of change-over valves provided in every block of heat exchangers such as, for example, in the case of a block consisting of six reversing heat exchanger units shown in FIG. 1 illustrating a conventional reversing heat exchanger system in an air separator, in such a manner that raw air compressed to approximately 5 atm. is fed from a pipe 1 through an open change-over valve $C_2$, pipe 2, main pipe 12, and respective flow rate control valves $D_1$ to heat exchangers $A_1$ through $A_6$, to be distributed thereto for being cooled to approximately $-170°$ C. upon heat exchange with a waste gas and other product gases, whereupon it is gathered into a main pipe 10 for passage through a pipe 3, a check valve $B_1$ and a pipe 4 leading to the next rectification process. On the other hand, waste gas of approximately 0.2 atm. being fed from the rectification system is distributed through pipes 5 and 6, check valve $B_2$, pipe 7 and main pipe 11 into the waste gas path of the heat exchangers and is gathered therefrom into a main pipe 13 through respective flow rate control valves $D_2$ associated with the units $A_1$ –$A_6$ at a normal temperature, and is then fed out of the separator through a pipe 8, and an open change-over valve $C_4$. Raw air of the reversing heat exchanger and waste gas, such as, for example, waste nitrogen, paths are exchanged by an exchanging operation of the change-over valves $C_1$ through $C_5$. For example, if the valves $C_2$ and $C_4$ are open and the valves $C_1$, $C_3$ and $C_5$ are closed, as just described, they are exchanged by closing the valves $C_2$ and $C_4$, thereby momentarily completely shutting off the raw air and gas flow paths, then opening the valve $C_5$ to equalize the pressure of the raw air and waste gas paths at approximately 2.6 atm., then closing the valve $C_5$, and finally opening the valves $C_1$ and $C_3$ in order to complete the exchange of the paths. In FIG. 1, the paths of product gases not concerned with the exchange are omitted.

Because such systems require not only complicated switching operations, but main pipes 10, 11, 12 and 13 for gathering the raw air and waste gas being fed into and from the respective heat exchangers, when the valve $C_5$ is opened for providing communication between the raw air and waste gas paths so as to equalize the pressure thereof, considerable amounts of raw air and waste gas are mixed in the block so that when the valve $C_1$ is opened, a considerable amount of raw air is discharged together with the waste gas, the result being that the loss of the raw air becomes significant. Also, since the pressure of the waste gas paths varies abruptly, a large noise is generated, so that a silencer is required. In addition, this abrupt pressure change breaks the gas-liquid equilibrium in the rectification process thus disturbing and making it difficult to maintain a stable rectification.

Further, as shown in FIG. 2, in an arrangement having a cooling tower 70 and an evaporative cooling tower 71, raw air supplied from a pipe 72 is cooled at the cooling tower 70 with water and the water is cooled by waste gas, or waste nitrogen, at the evaporative cooling tower 71, and waste gas is accordingly fed to the evaporative cooling tower 71. However, when raw air of approximately 5 atm. and waste gas of approximately 0.2 atm. are exchanged, the aforementioned abrupt pressure change occurs, and if the pressure change is effected directly at the evaporative cooling tower 71, the filler within the evaporative cooling tower may be ejected from the tower or be broken with the result that a three-way change-over valve 73 must be provided to avoid the effects of the pressure change by discharging the waste gas through a pipe 74 upon the exchange thereof.

### SUMMARY OF THE INVENTION

This invention contemplates the elimination of the aforementioned various disadvantages of presently available devices and the provision of a novel and improved reversing heat exchanger unit in which the reversing heat exchanger is not divided into blocks, and change-over valves and check valves are provided for each reversing heat exchanger unit so as to unify them whereby the loss of raw air may be decreased upon exchanging the raw air and the waste gas paths and the usual accompanying abrupt pressure changes are prevented to enable stable operation of the rectification system and to permit standardizing the change-over valves and check valves in order to facilitate easy design and manufacturing of reversing heat exchanger systems.

### BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description when considered in connection with the accompanying drawings, in which like reference numerals designate like or corresponding parts throughout the several views, and wherein:

FIG. 1 is a diagrammatic view of a conventional reversing heat exchanger system in an air separator;

FIG. 2 is a diagrammatic view of another conventional reversing heat exchanger system;

FIG. 3 is a side sectional view of one embodiment of a change-over valve constructed according to the present invention;

FIG. 4 is a side sectional view of one embodiment of a check valve constructed in accordance with the present invention;

FIG. 5 is a schematic illustration of another embodiment of a check valve constructed according to the present invention;

FIG. 6 is a schematic illustration of a reversing heat exchanger unit having the change-over valves and check valves of this invention;

FIG. 7 is an explanatory illustration of another reversing heat exchanger unit having the change-over valves shown in FIG. 3 and the check valves shown in FIG. 1;

FIG. 8 is an explanatory illustration of a further reversing heat exchanger unit having a change-over valve according to this invention provided with flow rate control valves;

FIG. 9 is an explanatory illustration of a reversing heat exchanger unit such as shown in FIG. 8 having an integral flow rate control valve incorporated therein; and

FIG. 10 is a diagrammatic view of an embodiment of a reversing heat exchanger system having six heat exchanger units constructed according to the present invention.

## DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Reference is now made to the drawings, particularly to FIG. 3, which shows one embodiment of a change-over valve constructed according to the present invention and comprising a pair of opposing valve bodies **41** and **42** positioned on a valve rod **43** to form three chambers $M_1$, $M_2$ and $M_3$ partitioned within the housing thereof having a nozzle **52** disposed in the central chamber $M_2$, and two nozzles disposed in each of the outer chambers at both ends thereof, namely nozzles **48** and **50** in chamber $M_1$ and nozzles **49** and **51** in chamber $M_3$, wherein the materials flowing in the path formed by the two nozzles in one of the outside chambers and a path formed by one nozzle in the other outside chamber and the nozzle in the central chamber may be readily exchanged by movement of the valve rod. Thus, the valve bodies **41** and **42** provide contacting surfaces **41*a***, **41*b*** and **42*a***, **42*b*** on the opposing surfaces thereof, respectively, so that the valve bodies **41** and **42** cooperate with the back and forth, or axial, movement of the valve rod **43** by an operating piston **44** to open the central chamber $M_2$ and its nozzle **52** to one of the nozzles of one of the outside chambers, while closing the other nozzle of the one outside chamber and also permitting flow through the other outside chamber from its one nozzle to the other. The nozzles **50** and **51** provided at the tops of the outside chamber $M_1$ and $M_3$, respectively, are nozzles communicating with the heat exchanger, thus providing an outlet of raw air and an inlet of waste gas, while the nozzles **48** and **49** respectively provided in the bottoms of the outside chambers $M_1$ and $M_3$ are inlet nozzles for raw air and the nozzle **52** provided in the central chamber $M_2$ is an outlet nozzle for waste gas.

The contacting surfaces **41*a*** and **42*a*** of the valve bodies **41** and **42** face the raw air inlets of the nozzles **48** and **49**, respectively, and the contacting surfaces **41*b*** and **42*b*** face the waste gas outlet of the nozzle **52** in their disposition in the valve housing forming the respective inlets and outlets. The operating piston **44** of the valve rod **43** is disposed within a cylinder having an inlet **46** and an outlet **47** for operating air, and a cushion **45** is provided at the other end of the valve rod **43** to be disposed within a cylinder therefor, but the mechanism for moving the valve rod **43** and the cushion mechanism obviously may take other forms capable of functioning the same.

In operation of the change-over valve, if operating air is fed into the cylinder from an inlet **46** so as to push the operating piston **44** leftwardly of the drawing, as shown in FIG. 3, the contacting surfaces **41*a*** and **42*b*** of the valve bodies **41** and **42** will close the path of the nozzle **48** and one of the paths of nozzle **52**, respectively, so that raw air flows from the nozzle **49** to the nozzle **51** and waste gas flows from the nozzle **50** to the nozzle **52**. Then, if operating air is reversely fed from outlet **47** into the cylinder end is exhausted from the inlet **46**, the operating piston **44** moves rightwardly as viewed in the drawing so that the contacting surfaces **41*b*** and **42*a*** of the valve bodies **41** and **42** close the path of nozzle **49** and another of the paths of nozzle **52**, respectively, with the result that the contacting surfaces **41*a*** and **42*b*** are separated from their seats. As a result, raw air flows from the nozzle **48** to the nozzle **50** and waste gas flows from the nozzle **51** to the nozzle **52** by one simple operation to complete the exchange thereof.

In this change-over valve, the surfaces of the valve bodies **41** and **42** facing the chambers $M_1$ and $M_3$ always receive the pressure of raw air. Thus, if the surface contacting the outlet of the nozzle **48** of the chamber $M_1$ is closed as shown in FIG. 3, the valve body **42** receives the force of $\pi PD^2/4$ from the surface thereof on the chamber $M_3$ side being applied leftwardly of the drawing, while the valve body **41** receives the force of $\pi Pd^2/4$ from the surface of the nozzle **48** side being applied rightwardly of the drawing, where D illustrates the diameter of contacting surfaces **41*b*** and **42*b*** of the chamber $M_2$ side, d the diameter of the contacting surfaces **41*a*** and **42*a*** of the raw air side, and P the pressure of the raw air. Consequently, the valve rod **43** receives the force of $P(D^2 - d^2)/4$ being applied leftwardly of the drawing. In order to move the rod **43**, if raw air of pressure P is used as operating air of the operating piston **44** to be supplied from the inlet-outlet arrangement **46** and **47**, the diameter of the operating piston **44** may be slightly larger than $\sqrt{D^2 - d^2}$, with the result that the cylinder containing the operating piston **44** may accordingly be kept small. In such case, though the sizes of the contacting surfaces **41*a***, **41*b*** and **42*a***, **42*b*** may be equalized, it then is necessary to enlarge the operating piston so as to obtain the surface pressure at the contacting surface required for their sealing, whereas the operating piston may be lessened if the contacting surfaces 41*b* and 42*b* are larger than the contacting surfaces 41*a* and 42*a* so as to obtain the surface pressure required for their sealing due to their area difference, as shown in FIG. 3.

It is advantageous since the raw air is compressed air of approximately 5 atm., the raw air may be used for the operating air of the operating piston 44.

Although the check valve used in this invention may be a pair of check valves heretofore known, as shown in FIG. 1, the check valve shown in FIG. 4, which shows one embodiment of a check valve constructed according to the present invention, is preferably employed.

This check valve comprises a body 20 divided into three adjacent chambers, including a central chamber $R_2$ and two outside chambers $R_1$ and $R_3$, by two partition walls 23 and two outer walls 29, the chambers respectively having normally open ports, and four valve bodies movable by pressure differences occurring between adjacent chambers and being mounted symmetrically at the center of the central chamber with two of the valve bodies disposed in the partition walls and the other valve bodies being disposed on the outer walls of the two outside chambers. More particularly, the three chambers $R_1$, $R_2$ and $R_3$ are partitioned by valve bodies 14, 15, 16 and 17 mounted on partition walls 23 and outer walls 29, and piping nozzles 30 through 34 are provided in each chamber. In this embodiment, the valve bodies 14, 17 and 15, 16 are oppositely mounted outwardly with respect to the central chamber $R_2$ and are connected to the partition walls 23 and outer walls 29 by valve bases 24 fixed thereto at one end thereof through sealing plates 25 fixed to one end of a movable arm 26 through a connecting pin 18, the sealing plate 25 contacting an area with the valve base 24 for sealing gas flow by the back pressure so as to open the valve body if the pressure on the surface 27 is larger than the back pressure.

In operation of the check valve constructed in this manner, raw air of approximately 5 atmospheres being supplied from the heat exchanger is fed into one chamber $R_1$ of the check valve through the piping nozzle 32 so as to seal the valve body 14 with a pressure of approximately 5 atm. and to open the valve body 15 with the same pressure, and is fed through the chamber $R_2$ from the piping nozzle 34 into a rectification system. On the other hand, waste gas of approximately 0.2 atmospheres fed from the rectification process opens the valve body 17 being introduced from the nozzle 31 into chamber $R_3$ of the check valve to be fed therefrom through the nozzle 33 to the heat exchanger.

In this case, since the valve body 16 receives pressure of approximately 0.2 atm. from the waste gas upon the front surface, but also receives a back pressure of approximately 5 atm. from the chamber $R_2$ side, it remains closed.

Then, if the fluid flow paths passing through the heat exchanger are exchanged, the valve bodies 14 through 17 in the check valve are opened or closed oppositely, raw air always flowing into the central chamber $R_2$ so that the fluid passing through both chambers $R_1$ and $R_3$ flows oppositely.

Although in the above embodiment of the check valve, the valve bodies 14, 17 and 15, 16 are mounted oppositely and outwardly, it also may be possible to mount the valve bodies 14, 17 and 15, 16 inwardly with respect to the central chamber $R_2$, which case is shown in FIG. 5.

The check valve of the embodiment shown in FIG. 5 comprises three chambers $R_1'$, $R_2'$ and $R_3'$ partitioned by partition walls 23, outer walls 29' and valve bodies 14, 15, 16 and 17, and spaces $S_1$ and $S_2$ are provided in the range of the movable valve bodies 14 and 17 at the mounting portions of the nozzles 30 and 31.

In operation of a check valve so constructed, raw air of approximately 5 atm. supplied from the heat exchanger is fed through the nozzle 32 into the chamber $R_1'$ to open the valve body 14 and is supplied through the nozzle 30 into the rectification system, not shown. On the other hand, waste gas of 0.2 atm. supplied from the rectification system is fed through the nozzle 34 into the central chamber $R_2'$ to open the valve body 16 and is supplied from the nozzle 33 into the heat exchanger. Here, since the valve body 15 receives a front surface pressure of approximately 0.2 atm. from the chamber $R_2^1$ side, but also receives a back pressure of approximately 5 atm. from the chamber $R_1'$ side, it is closed, and since the valve body 17 similarly receives a front surface pressure of approximately 0.2 atm. from the chamber $R_3'$ side but also receives the pressure of raw air, i.e., a back pressure of approximately 5 atm. from the space $S_2$ communicating with the nozzle 31, it remains closed. Then, if the paths of the heat exchanger are exchanged, the valve bodies 14 through 17 are opened or closed in an opposite fashion so that raw air is supplied through the heat exchanger, nozzle 33, chamber $R_3'$, and nozzle 31 into the rectification system, while waste gas is fed through the nozzle 34, chambers $R_2'$ and $R_1'$, and nozzle 32 into the heat exchanger.

Referring now to FIG. 6, there is shown a reversing heat exchanger unit having a change-over valve and check valve wherein the check valve B is provided at the low-temperature side of the reversing heat exchanger A while change-over valve C is provided at the high temperature side thereof.

In operation of this reversing heat exchanger unit, in case of an all low-pressure type air separator, raw air of approximately 5 atm. is fed from the nozzle 48 of the change-over valve C through the nozzle 50 as designated by an arrow in FIG. 6, then into the heat exchanger body so as to exchange heat with the counter current waste gas for being cooled to approximately −170° C. and is then fed from the nozzle 32 into the chamber $R_1$ of the check valve B to seal the valve body 14 by a pressure of approximately 5 atm. and to open the valve body 15 by the same pressure and whereafter it is supplied from the chamber $R_2$ through the nozzle 34 to the rectification system or the lower portion of a rectification tower, not shown. On the other hand, waste gas of approximately 0.2 atm. from the upper portion of the rectification tower opens the valve body 17 to be introduced into the chamber $R_3$ of the check valve B from the nozzle 31 then through the nozzle 33 to heat exchanger A to become substantially normal in temperature, and is then fed through the nozzle 51 into the change-over valve C so as to be fed from the nozzle 52 into the pipe for feeding out the waste gas. If the raw air and waste gas paths in the heat exchanger are exchanged, operating air is fed into the piston chamber of the change-over valve C from the inlet 46 and operating air from the outlet 47 is exhausted, so that the operating piston 44 moves leftwardly of the drawing with the result that the contacting surfaces 41*a* and 42*b* of the valve bodies 41 and 42 close the communicating portions between the nozzles 48 and 50 and 51 and 52 and the contacting surfaces 41*b* and 42*a* are separated from their seats. Consequently, raw air is fed from the nozzle 49 and through nozzle 51, while waste gas is fed from the nozzle 50 and through the nozzle 52, the exchange being effected by one simple operation. Since the pressures before and after the valve bodies 14 through 17 of the check valve are varied by the exchanging operation of the change-over valve C, the valve bodies 14 and 16 are opened, while the valve bodies 15 and 17 are closed, to complete the exchange operation, and raw air is supplied from the nozzle 33 through the chambers $R_3$ and $R_2$ and the nozzle 34, then into the rectification process, while waste gas is supplied from the nozzle 30 through the chamber $R_1$ and the nozzle 32, then into the heat exchanger.

In FIG. 6, since the product gas paths of the reversing heat exchanger have no relation to the exchange thereof, they are omitted. And, since the product gas paths are not related even in the following aspects, they will be omitted hereinafter also.

Reference is now made to FIG. 7, which shows the reversing heat exchanger unit having the change-over valve shown in FIG. 3 and the check valves known heretofore, as shown in FIG. 1.

The upper nozzles 50 and 51 provided in the outside chambers $M_1$ and $M_3$ of the change-over valve C are connected to the high temperature side of the heat exchanger A, while a pair of check valves $B_1$ and $B_2$ are connected to the low temperature side thereof, so that these are unified.

In operation of the reversing heat exchanger unit so constructed, raw air is fed through the nozzles 48 and 50 of the change-over valve C into the heat exchanger A and then through the check valve $B_1$ into the rectification system, while waste gas is fed through the other check valve $B_2$ into the heat exchanger A and further through the nozzle 51 of the check valve C and the central chamber $M_2$ to the nozzle 51 and then into the pipe for feeding out waste gas. The exchange of the raw air and waste gas paths of the heat exchanger is as previously described.

Referring now to FIG. 8, there is shown a further embodiment of the reversing heat exchanger unit illustrated in FIG. 6, having flow control valves $D_1'$, $D_1''$ and $D_2'$ provided in the nozzles 48, 49 and 52, respectively, of the change-over valve C.

As seen from the description of the reversing heat exchanger unit shown in FIG. 6, in the operation of this heat exchanger unit, since waste gas flows through the nozzle 52 of the change-over valve C regardless of their exchange while only raw air passes through the nozzles 48 and 49, the flow rate control valves $D_1'$ and $D_1''$ always adapt for raw air flow so as to adjust the valve opening, while the flow rate control valve $D_2'$ always adapts for waste gas flow so as to adjust the valve opening. If the change-over valve is operated after these flow rate control valves $D_1'$, $D_1''$ and $D_2'$ are closed, the pressure of raw air and waste gas paths may be equalized.

Reference is now made to FIG. 9, which shows still another embodiment of a reversing heat exchanger unit having an integral flow rate control valve unifying the flow rate control valves $D_1'$ and $D_1''$ of raw air into a single unit and wherein the other components are the same as those in the unit shown in FIG. 8. The reversing heat exchanger unit shown in FIG. 7 may also be supplied with the flow rate control valves used in the units shown in FIGS. 8 and 9, without other modification, if desired.



Referring now to FIG. 10, another embodiment of a reversing heat exchanger system using six heat exchanger units constructed according to the present invention, as shown in FIG. 8, is illustrated. In operation, raw air supplied from the main pipe 60 is supplied through change-over valves $C_1'$ through $C_6'$ to heat exchanger units $A_1$ $_1$through $A_6$, then through check valves $B_1'$ through $B_6'$ to be gathered in the main pipe 63 for passage to a rectification process, while waste gas is gathered from the main pipe 62 through check valves $B_1'$ through $B_6'$, heat exchangers $A_1$ through $A_6$, and change-over valves $C_1'$ through $C_6'$, being collected in the main pipe 61 to be fed out of the exchanger. Here, flow rate control valves $D_1'$, $D_2''$ and $D_2'$ correspond to the flow rate control valves $D_1$ and $D_2$ shown in FIG. 1 for controlling the flow rate of raw air and waste gas passing through the heat exchanger. In FIG. 1, since raw air and waste gas flow alternatively through the flow control valves $D_1$ and $D_2$ in every exchange of flow paths, its control was difficult, but if the instant reversing heat exchanger unit is adopted, raw air always flows through the flow rate control valves $D_1'$ and $D_1''$, while waste gas flows always through the flow rate control valve $D_2'$, and accordingly it is very easy to control the flow rate thereof. And, since the flow rate control valves $D_1'$ and $D_2'$ are closed upon exchange, the pressure of raw air and waste gas may be equalized upon exchange.

It should be understood from the foregoing description that the following effects and advantages are provided by improving the conventional art in a manner suggested by this invention.

*a*. Since the respective reversing heat exchanger units are not formed in blocks but are unified, it may be freely exchanged in response to the respective types of the exchanger.

*b*. Since the design condition of the capacity of the air separation plant depends only upon the number of the reversing heat exchanger units, a plan or schedule may be quickly and accurately conducted.

*c*. Since the treating capacity of the unit is constant, the capacity of the change-over valve and check valves become constant accordingly so that they may be unified to provide a mass production and thus to improve the quality of the product and to cut costs.

*d*. Since the change-over valves and check valves are directly mounted to be unified in the respective reversing heat exchanger unit, the main pipes 10 and 11 between the check valves and the heat exchanger and the main pipes 12 and 13 between the heat exchanger and the change-over valve are unnecessary, the exchange capacity or volume between raw air and waste gas becomes minimum so that the exchange loss of raw air is reduced 25 to 40 percent in comparison with the conventional types, and further, exchange noise may be lessened to an extent impossible in the conventional exchanger without use of a silencer.

*e*. Though the pressure due to the closing are of the change-over valves upon exchange breaks the gas-liquid equilibrium in the conventional reversing heat exchanger having blocks of heat exchangers, the respective unit may be independently exchanged in the device of this invention, and accordingly tentative pressure increase thereof is sufficiently absorbed by the main pipes **62** and **63** shown in FIG. **10** to have no affect on the rectification system and thus to provide a stable rectification.

*f.* If the unit of this invention is adopted, the height of the cold box of the heat exchanger of the air separator may be lowered so as to decrease the volume of the box 20 to 30 percent in comparison with conventional exchangers.

*g.* If one block of reversing heat exchanger units is exchanged by **4** or **5** change-over valves as heretofore practiced, it is necessary to exchange the respective valves in cooperation with each other, and accordingly if any one becomes defective in operation, raw air and waste gas are mixed to badly affect the air separator, but in the unit of this invention, the exchange period of the unit provided with the change-over valve is merely lengthened, and even if the change-over valve becomes defective in operation it will not affect the separator, whereby the stability of the separator is improved.

*h.* Since the fluids passing through the respective flow rate control valves are not related to the exchange of the flow paths but are always the same through the provision of the flow rate control valves $D_1'$, $D_1''$ and $D_2'$, shown in FIG. **8**, and valves $D_1'$ and $D_2'$, shown in FIG. **9** in the paths of the nozzles **48**, **49** and **52** of the change-over valves, it is extremely simple and easy to control the flow rate of the fluid.

*i.* Raw air and waste gas paths in the reversing heat exchanger unit may be readily equalized in pressure merely by closing fully the flow rate control valves shown in FIGS. **8** and **9**.

Obviously many modifications and variations of the invention are possible in light of the above teachings. Accordingly, it is therefore to be understood that within the scope of the appended claims this invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

**1.** A reversing heat exchanger unit for performing a heat exchange operation between two gases, comprising:

a reversing heat exchanger;

a change-over valve connected to the high-temperature side of said reversing heat exchanger;

a check valve connected to the low-temperature side of said reversing heat exchanger; and

flow rate control valves connected to said change-over valve,

wherein the change-over valve is a housing divided into two side chambers and a central chamber with a nozzle, the side chambers each having two other nozzles with one of the nozzles of each side chamber being connected to the high-temperature side of the heat exchanger, a flow path for one of said gases being formed by each of the nozzles connected to the high-temperature side of the heat exchanger and the nozzle in the central chamber, an alternate flow path for the other one of said gases being formed by each of the nozzles connected to the high-temperature side of the heat exchanger and the other nozzles in the respective side chamber, and valve means in said housing for exchanging the paths being formed therein between the nozzles, and wherein further, said flow rate control valves are connected to said other nozzles of said side chambers and said nozzle of said central chamber.

**2.** A reversing heat exchanger unit according to the claim **1**, wherein said check valve is a housing having three chambers formed by a pair of spaced partition walls and opposite outer walls of said housing, each of said three chambers having a normally open port and four valve bodies positioned one each in each of said walls being movable by pressure difference between adjacent chambers and mounted symmetrically from the center of the central chamber.

**3.** A reversing heat exchanger unit according to claim **1** wherein said valve means in said housing of said change-over valve comprises:

a pair of valve bodies mounted on a valve rod axially movable within said housing;

each of said pair of valve bodies having opposing contacting surfaces for alternately opening and closing a different one of said paths formed by said nozzles connected to the high temperature side of said reversing heat exchanger and the nozzle of said central chamber and the paths formed by the same said nozzles connected to the high-temperature side of said heat exchanger and said other nozzles in the same chambers upon movement of said valve rod.

**4.** A reversing heat exchanger unit according to claim **3**, further comprising a cylinder and a fluid pressure-operated piston connected to one end of said valve rod and slidable within said cylinder for moving said valve rod.

**5.** A reversing heat exchanger unit according to claim **1** wherein said flow rate control valves are respectively provided in a gathering pipe communicating with said other nozzles of said side chambers not connected to the high-temperature side of said heat exchanger and in the nozzle in said central chamber.

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