Oct. 26, 1971 **G. C. LE LARA ET AL** **3,615,079**

GAS HEAT EXCHANGER HAVING LIQUID HEAT CARRIER

Filed March 22, 1968 4 Sheets-Sheet 1

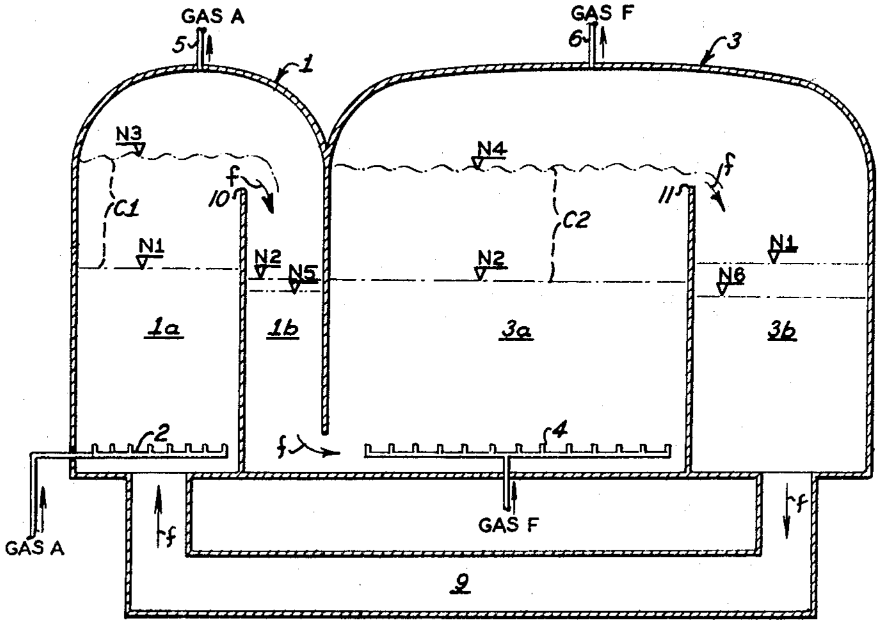

FIG. 1

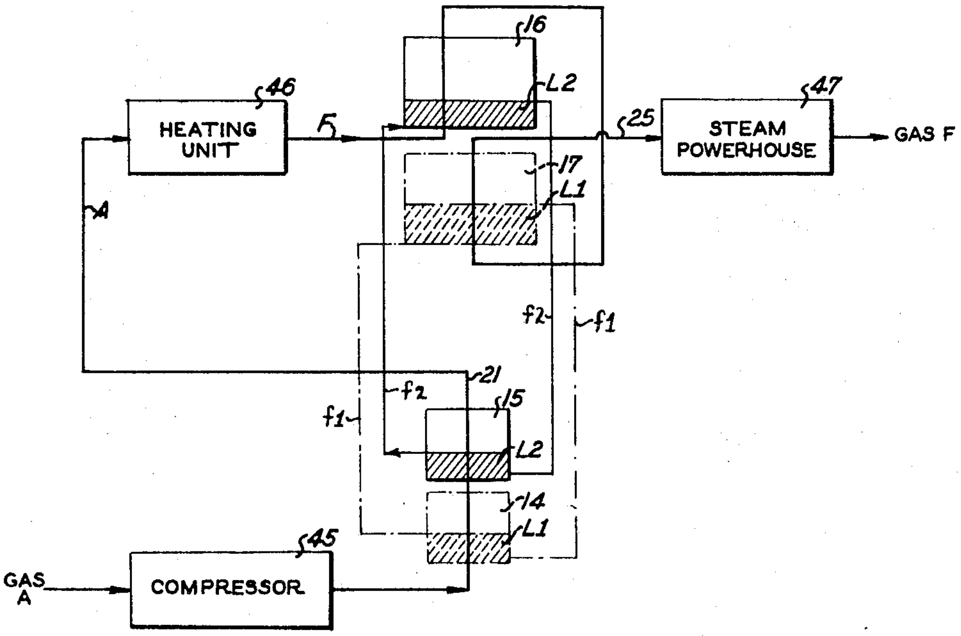

FIG. 5

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GAS HEAT EXCHANGER HAVING LIQUID HEAT CARRIER

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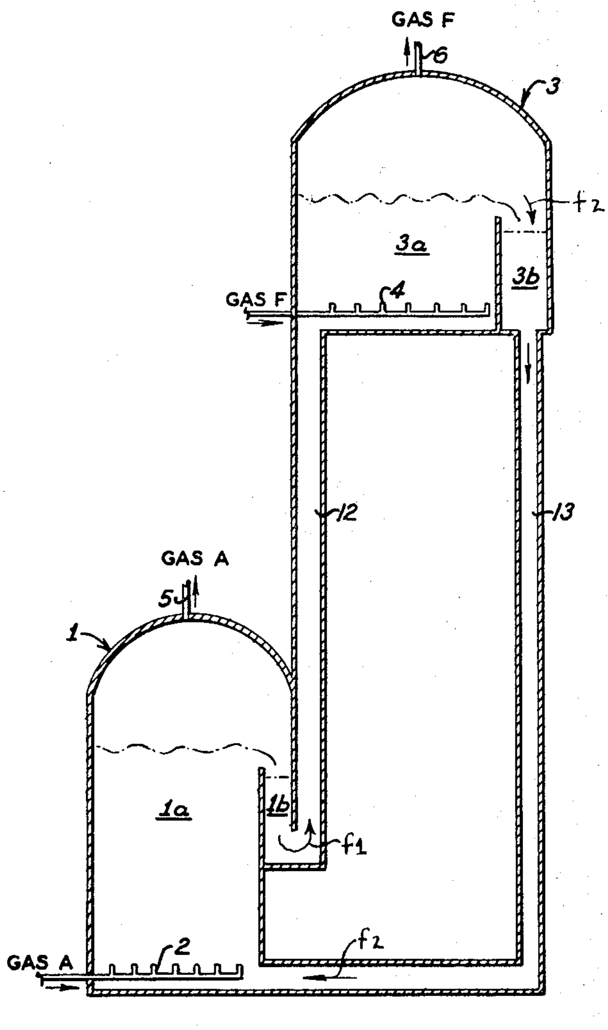

FIG. 2

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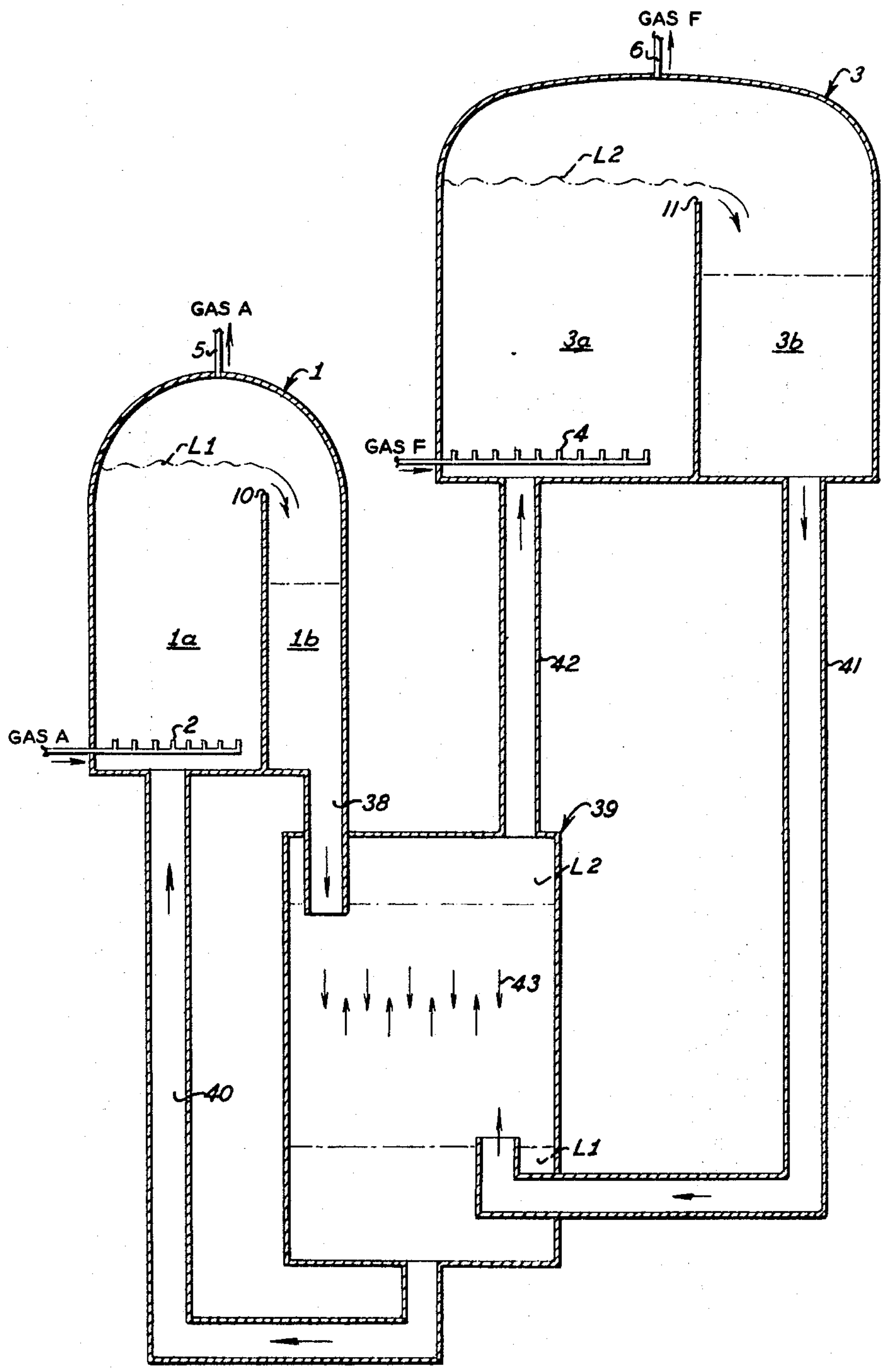

FIG. 3

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GAS HEAT EXCHANGER HAVING LIQUID HEAT CARRIER

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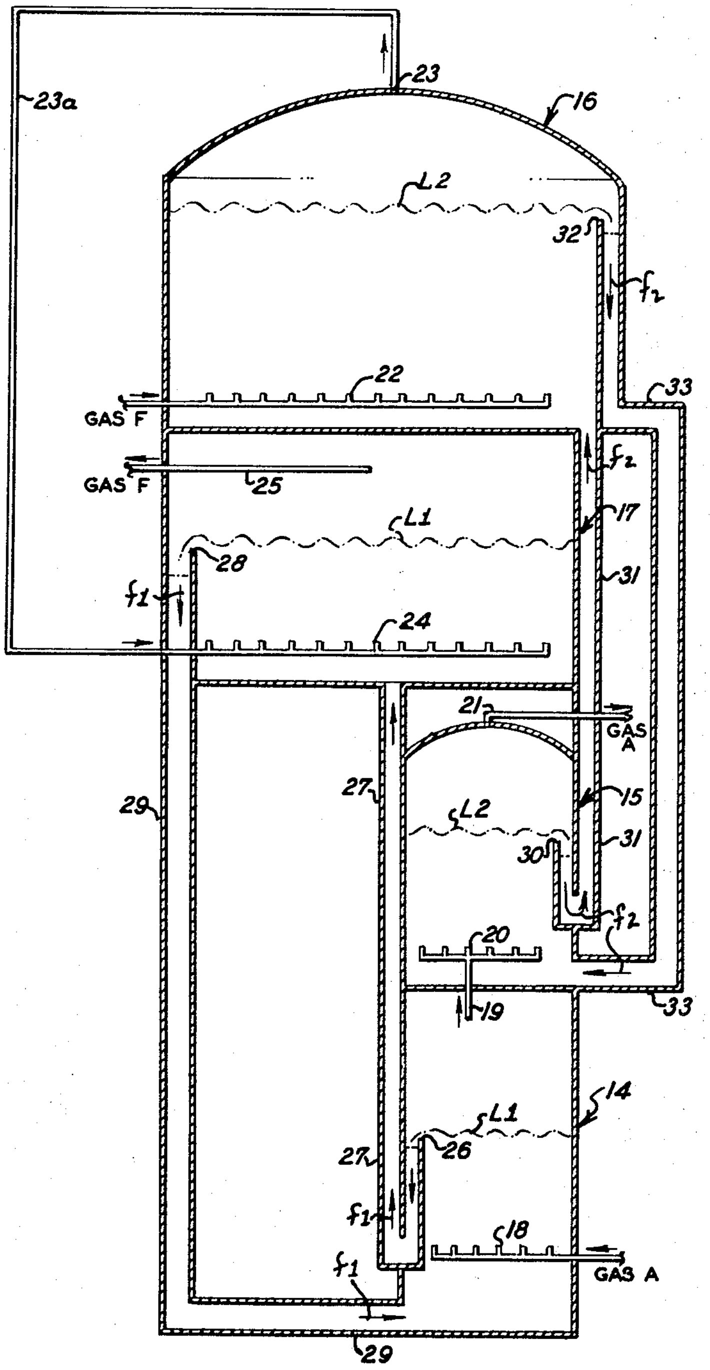

FIG. 4

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GAS HEAT EXCHANGER HAVING LIQUID HEAT CARRIER

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Int. Cl. B01f 3/04
U.S. Cl. 261—146 8 Claims

ABSTRACT OF THE DISCLOSURE

In this exchanger a gas to be cooled or heated is placed in direct contact with a liquid heat carrier by bubbling the gas therethrough.

This invention relates to heat exchangers and more particularly to heat exchangers for the transfer of heat in gases.

The transfer of heat between two gases is generally performed in heat exchangers having two gas circuits separated by walls through which the heat transfer is carried out. Recovery apparatus, such as those constructed from bricks arranged in stacks, is also employed for such purpose. If a battery of such recovery plants or Cowper is available, judicious combinations of the same enable differences in temperature to be restricted in each of the gases. However, such a system is basically discontinuous and sluice gates have to be operated at each changeover; the frequency of these changeovers depending on the variations in temperatures that are acceptable.

It has been found that this transfer may be equally effected without an exchange wall, by using, for example, chambers in which a suitable liquid is dispersed in droplet form in an ascending gas current. An initial transfer takes place in one chamber and enables a gas to be cooled, for example, by imparting heat to the liquid. This heated liquid is then introduced in the same way into a second chamber where it is similarly employed to impart heat to the gas for reheating. The liquid is carried between the transfer walls by means of pumps. A similar arrangement may be used employing finely divided fluidized solid substances that are conveyed by pneumatic transporters or mechanical lifts. Mixed solutions are also possible. As a heat carrier one may use a body which may be in the form of a liquid dispersed in drops, or in the form of a finely divided solid, fluidized in the current of gas.

It is the primary purpose of the present invention to provide a heat exchanger which is essentially characterized by bringing a gas and a liquid heat carrier into direct contact through bubbling the gas in the liquid heat carrier to effect an exchange of heat therebetween, and by utilizing the bubbling action of the gas in the liquid heat carrier to effect the circulation of the latter.

A heat exchanger, in accordance with the invention, has at least two transfer chambers which contain a certain quantity of liquid heat carrier. Each of the chambers is divided into two compartments which are connected by one or more overflows. A gas is introduced at the base of the first compartment of the first chamber over the entire transverse section thereof, to enable it to bubble upwardly in the liquid contained in such compartment, and is discharged above the surface of such liquid into the upper part of the first chamber, and finally emerges from the top of the chamber. The liquid heat carrier contained in said first compartment, atomized by the gas, rises above the overflow, or overflows of the first compartment. The overflow, or overflows are configured and dimensioned to cause degasification of the liquid heat carrier as such carrier passes thereover and enters the second compartment of the first chamber. The gas which has thus been separated from the carrier passes out through the top of the chamber, while the carrier entering said second compartment passes into the first compartment of the second chamber through a conduit connecting both chambers.

A gas is also introduced at the base of and over the entire cross-section of the first compartment of the second chamber and bubbles upwardly in the liquid heat carrier contained in such first compartment, to be discharged above the surface of such liquid into the upper section of the second chamber from which it finally emerges at the top thereof. The liquid heat carrier contained in such first compartment of the second chamber, atomized by the gas, rises above the overflow or overflows of such compartment, which as the liquid carrier passes thereover to enter the second compartment of said second chamber, causes the degasification of such carrier. The separated gas passes out through the top of the second chamber. The liquid heat carrier discharged into said second compartment is conducted to the first compartment of the first chamber through a second conduit joining both chambers.

The communicating ducts and the overflow, or overflows of both chambers are constructed and arranged in accordance with the practices of this art to distribute and discharge the liquid heat carrier in an efficient manner. The chambers may also be adjusted for height in a known manner, as by means of wedges, one with respect to the other, so that the columns of liquids existing in the conduits joining the chambers, may compensate for the difference in pressure between the two chambers. If the gases are of different pressure, the height of wedging may also depend on the difference in the density of the liquids used in the two chambers. In the event that the nature of the gases used in the two chambers is such that they cannot be in contact with the same liquid without involving troublesome physio-chemical reactions, the circuit may be formed with two different liquids. The two liquids chosen should be immiscible and of different densities and the circuit should additionally include an intermediate chamber in which the two liquids are brought into contact to ensure the transference of heat from one liquid to the other. This intermediate chamber should be so constructed and arranged as to enable the two liquids after being brought into contact, to be separated, as by, for example, the phenomenon of density.

In a two-chamber apparatus, the liquid entering at temperature T1 into the first chamber is cooled to temperature T2, while the gas introduced is raised to a temperature of approximately T2. The liquid entering the second chamber at temperature T2 heats up to a temperature T1, while the gases are cooled down to a temperature of approximately T1. Therefore, there is a fall in temperature slightly above (T1–T2) between the two gases leaving the heat exchanger. This difference may be reduced or increased by adjusting the volume of flow in circulation. If it is desired to reheat a cooled gas to a temperature above that at which the hot gas is cooled, it is necessary to provide a larger number of chambers in an apparatus, as will hereinafter be shown. Thus, the invention comprehends the use of four chambers, for example. In this latter case, there may be one single flow of liquid that traverses the four chambers successively, but it is of greater advantage to provide two separate flows of liquid heat carriers, each of which is associated with two chambers. In such a system, the gas flows are so arranged that the cold gas to be reheated is bubbled successively into the first and then into the second flow of liquid heat carrier, while the hot gas, which is to be cooled, is bubbled successively into the second and then into the first flow of liquid heat carrier. In the use of two or more heat carrier circuits, it is contemplated also that different liquids may be employed for each circuit.

In an apparatus according to this invention, the heat exchangers are effected to excellent advantage because of the direct contact between the liquid and the gas bubbling therethrough enables in the extremely brief contact time, an achieved transference which is practically equal to 1. This introduction of the gas into the liquid may be accomplished by any conventional means suitable to the particular problem at hand. For example, pierced nozzles may be used at the ends of the chambers, or porous elements may be provided in calcined materials. It is also possible to use racks made from perforated tubes.

The total losses in the materials employed in such a heat exchanger are very small and are composed of losses in the introduction system and losses due to bubbling in the liquid heat carrier, these latter losses being dependent on the density of the liquid and the height of the liquid in the compartment.

As has been previously indicated, a feature of the invention is the utilization of the bubbling of the gas in the liquid heat carrier, as the prime mover by which such liquid is circulated. An exchanger where the liquid heat carrier is so circulated by the gases themselves, does not require the use of a mechanical system. Accordingly, it is of special advantage in those exchangers where the provision of pumps or sluice-gates is accomplished with considerable difficulty. For example, it is particularly applicable where very high temperatures, or strongly corrosive atmospheres are present in the exchangers.

The choice of the liquid heat carrier depends not only on prevailing heat conditions, but also on physio-chemical characteristics. Thus, there should be chemical stability in the presence of the gases used and the contaminants therein, for otherwise the gases may oxidize or reduce, and where two gases are employed, one of the gases may oxidize while the other reduces. The liquid heat carrier also should have a vapor pressure low enough to ensure that the movements involved in the vapor phase remain very limited.

For a better understanding of the present invention, reference is made to the following description which should be read in connection with the accompanying drawings, in which

FIG. 1 is a diagrammatic vertical sectional view of a heat exchanger embodying the invention;

FIG. 2 is a similar view of another embodiment of the invention;

FIG. 3 is a similar view of a heat exchanger embodying the invention in which the carrier circuit is composed of two different liquids;

FIG. 4 is a similar view of another embodiment in which the heat exchanger is composed of several stages; and

FIG. 5 is a diagrammatic view of an installation embodying the invention.

Referring now more particularly to the heat exchanger apparatus shown in FIG. 1 of the drawings, the reference numeral **1** indicates generally a first heat transfer chamber composed of a first compartment **1***a* and a second compartment **1***b*. The reference numeral **3** indicates generally a second heat transfer chamber which is also composed of a first compartment **3***a* and a second compartment **3***b*. The apparatus contains a liquid heat carrier C which, when at rest in the chambers reaches the levels in the compartments thereof indicated by the dotted lines N1 and N2.

A gas A, the temperature of which is to be raised, is introduced into compartment **1***a* of the first chamber through a rack **2** located at the bottom of such compartment and caused to bubble upwardly through the liquid C1 in such compartment. A gas F, the temperature of which is to be lowered, is introduced into compartment **3***a* of the second chamber through a rack **4** located at the bottom of such compartment and caused to bubble upwardly through the liquid C2 in such compartment **3***a*. As soon as the gases A, F are introduced, the liquid in the compartments **1***a*, **2***a* is atomized by the discharge of gas. In this connection, it will be noted that the concentrations of the gas being injected into the liquids C1 and C2 are governed by the nature of the liquids present on the specific discharges of gas. As a result of the gases entrained in the liquids C1 and C2 thus atomized, the open surface of the liquid C1 in compartment **1***a* rises to the level N3 located above the overflow **10** between the compartments **1***a*, **1***b*, and the open surface of the liquid C2 in compartment **3***a* rises to the level N4 located above the overflow sill **11** between the compartments **3***a*, **3***b*. Under these conditions, the liquid in compartment **1***a* will flow over the overflow **10**, through compartment **1***b* and into compartment **3***a*, then over the overflow **11** into compartment **3***b* from whence it is returned by conduit **9** to compartment **1***a*. The circulation of the liquid through the apparatus as a result of the bubbling of the gases is indicated by the arrows *f*. During such circulation of the liquid, the liquid in the compartments **1***b* and **3***b* will be found to be at the levels N5, N6, respectively.

The gas A, after reheating, leaves chamber **1** through an outlet **5** in the upper part of such chamber, and the cooled gas F leaves chamber **3** through an outlet **6** at the upper part of such chamber.

It will be observed that in the operation of the above described apparatus, the discharges QA of gas A and QF of gas F through the racks **2** and **4**, respectively, determine the discharges QC1 and QC2 of liquids C1 and C2, respectively, between the compartments. Since the system is to be maintained at a stable permanent pattern, the levels in **1***b* and **3***b* become established very quickly, for $QC1=QC2=QC$, when taking into consideration the losses in load from each of the connected flows and the known principles governing the level of outflow in each of the overflows. If then the quantity of liquid contained in the apparatus is increased, the levels rise in compartments **1***b* and **3***b* and the flow QC increases. On the other hand, if the quantity of liquid present in the apparatus is decreased, there is brought about a corresponding diminution in the flow QC of circulating liquid heat carrier. The maximum discharge is reached when the overflows are completely submerged.

The gases will be introduced at a speed depending on the nature of the liquids and the gas. For example, the gas may be introduced at a speed of the order of 1 meter per second so as to form a sufficient spatial concentration of gas in the heat transfer compartments **1***a* and **3***a*. The dimensions of each of the chambers are determined by the ratio of the volume of discharge of the gas under the conditions of temperature, to the speed of introduction thereof adopted. Having regard to the nature of the gases, their volumetric discharge, and their input temperature, the equation of thermic balance will give the output temperature of the gases for a given outflow of liquid.

In those cases where the flows of gases A and F are at different pressures, the two chambers **1** and **3** should not be maintained on the same horizontal level as shown in FIG. 1, but should be arranged at different heights as is shown in FIG. 2 of the drawings. In the construction of FIG. 2, the gas A is injected into the compartment **1***a* of chamber **1** by the rack **2** at a high pressure, and the gas E is injected into the compartment **3***a* of chamber **3** by the rack **4** at a low pressure. In order to compensate for the difference in pressure between the two gases, the chamber **3** is set at a given level above chamber **1** so that the ducts **12** and **13** connecting the flows between the two chambers will form two columns of liquids capable of compensating for such difference in pressure. The liquid heat carrier will circulate between the two transfer chambers **1** and **3** in the manner shown by the arrows *f*.

As previously indicated, it is possible that a single liquid heat carrier may not be suitable for the two gases in the apparatus of FIG. 1. In that case, an apparatus of the type shown in FIG. 3 of the drawings may be employed. In the apparatus shown in FIG. 3; the transfer chamber **1** contains a first liquid heat carrier L1 which having been atomized in the compartment **1***a* by the gas A injected into it by the rack **2**, passes over the overflow **10** to be discharged into the compartment **1***b* from where it passes through a conduit **38** into the top of an intermediate chamber **39**.

The intermediate chamber is completely filled with two liquid heat carriers, the liquid heat carrier L1 from chamber **1** and a liquid heat carrier L2 from chamber **3**. The liquid heat carrier L1 is more dense than the liquid heat carrier L2 and is immiscible therewith. Consequently, when the liquid heat carrier L1 is discharged into chamber **39** through the conduit **38** it will sink to the bottom of such chamber and re-emerge there to be reunited by way of the duct **40** with the heat carrier L1 in compartment **1***a*.

The second, less dense, liquid heat carrier L2 after having been atomized in compartment **3***a* by the gas F injected thereunto by the rack **4**, passes over the overflow **11** to reach compartment **3***b* from where it is conveyed through a conduit **41** to the base of the intermediate chamber **39**. The liquid L2 discharged into chamber **39** rises in the latter and re-emerges at the top thereof to be reunited with the liquid L2 in compartment **3***a* by way of the duct **42**.

It will be noted from the above discussion of FIG. 3, that the apparatus depicted therein provides two independent heat carrier flows, one containing the liquid L1 and the other the liquid L2. The heat exchange between these two immiscible liquids is accomplished by countercurrent contact of such liquids in the intermediate chamber **39**. The denser liquid L1 arrives at the top of the chamber **39** and falls downwardly in such chamber. The less dense liquid L2 is supplied at the bottom of chamber **39** and rises upwardly in the same. Thus, by selecting two appropriate immiscible liquids of different density and passing them into an intermediate chamber in the manner indicated, they will both exchange heat by contact in such chamber as is indicated by the arrows **43** in chamber **39**, and then separate again so that one will discharge through the base of the chamber and the other through the top thereof. As a result of the heat exchanges within the transfer chambers **1** and **3**, the discharge temperature of the hot gas F at the outlet **6** of chamber **3** will exceed the discharge temperature of the heated cold gas A through the outlet **5** at the top of chamber **1**.

FIG. 4 of the drawings shows a heat exchange apparatus comprising two transfer chambers **14** and **15** for heating the cold gas A, and two transfer chambers **16** and **17** in the flow of the hot gas F, and using a first liquid heat carrier L1 in the transfer chambers **14** and **17** and a second liquid heat carrier L2 in the transfer chambers **15** and **16**. The path of flow of the liquid L1 between the chambers **14** and **17** is indicated by the arrows *f1*, and the path of flow of the liquid L2 between the chambers **15** and **16** is indicated by the arrows *f2*.

In the apparatus of FIG. 4, the gas A to be reheated, is introduced, for example, at a temperature of 400° K. through the rack **18** in the first transfer chamber **14** where it bubbles up through the liquid heat carrier L1 in this chamber and emerges in the upper portion of such chamber at a temperature of 1240° K. The liquid L1 in chamber **14** will be lowered from a temperature of 1450° K. to 1240° K. The heated gas A passes out through an outlet **19** in the top of chamber **14** and is fed by such outlet into a rack **20** in the second chamber **15**. When the gas emerges from the liquid L2 in chamber **15** it will be reheated to a temperature of 1800° K., while the liquid in this chamber will be decreased in temperature from 1955° K. to 1800° K. The gas at its reheated temperature of 1800° K. is removed from the upper part of chamber **15** through an outlet **21** in its top.

The gas F is initially introduced at a temperature of 2300° K. through a rack **22** in chamber **16**. The gas F bubbles upwardly from rack **22** through the liquid heat carrier L2 in this chamber and emerges from such liquid at a temperature of 1955° K.; the liquid increasing in temperature as a result of the gas passing therethrough from 1800° K. to 1955° K. The cooled gas F passes from chamber **16** through an outlet **23** at its top, and is conducted through a pipe **23***a* to the distributing rack **24** in the fourth transfer chamber **17**. After bubbling through the liquid L1 in chamber **17**, the temperature of the gas will have decreased to 1450° K., while the temperature of the liquid L1 will have increased from 1240° K. to 1450° K. The cooled gas is removed from the chamber **17** through an outlet **25** in the upper part thereof.

The circulation of the two liquid heat carriers L1 and L2 in the apparatus of FIG. 4 takes place as follows:

The liquid L1 in the transfer chamber **14** is atomized and entrained by the discharge of the gas A from the rack **18**. As a result it rises above the overflow **26**, and discharges over the latter into a conduit **27** which causes it to flow toward the transfer chamber **17** into which it enters. In chamber **17** the liquid L1 is carried forward by the flow of gas F passing through the rack **24** and flows over the overflow **28** into a conduit **29** which returns it to the chamber **14**, thereby completing the circuit of flow of such liquid.

The circulation of the second flow of the liquid heat carrier L2 is similarly established between the heat transfer chambers **15** and **16**. The liquid L2 in the transfer chamber **15** passes over the overflow **30** and into the conduit **31** which conducts it into chamber **16**. In chamber **16**, under the influence of the gas F discharged through the rack **22**, the liquid L2 flows over the overflow **32** and into a conduit **33** which returns it into the chamber **15**.

The apparatus of FIG. 4 operates under conditions, such that the temperature equilibrium between the gases and the liquids is vertically established in the course of the bubbling operations. FIG. 5 of the drawings shows in diagrammatic form apparatus of the type disclosed in FIG. 4 arranged in the circuit of an electric powerhouse for the production of magneto-hydrodynamic electric current.

In the diagrammatic showing of FIG. 5, the heat transfer chambers **14**, **15**, **16** and **17** correspond to those shown in FIG. 4 of the drawings. In FIG. 5, the flow of the liquid heat carrier L1 between the chambers **14** and **17** is indicated in dotted lines and its direction of circulation is indicated by the arrows *f1* as in FIG. 4. Similarly, the flow of the liquid heat carrier L2 between the chambers **15** and **16** is indicated by solid lines and its direction of circulation is indicated by the arrows *f2*.

The gas A to be reheated is compressed at **45** in a known manner to 5 kgs. of absolute pressure before it is introduced into the transfer chamber **14** as previously described at 400° K. It then passes through the transfer chamber **15** to re-emerge at the outlet **21** at 1800° K. The gas A is then conducted with the requisite fuel into the burner and the tubing of the magnetic-hydrodynamic unit **46** from which it emerges in the form of fumes at a temperature of 2300° K. These hot fumes pass through the two heat transfer chambers **16** and **17** in the manner previously described at an absolute pressure of 1 kg. When the fumes emerge through the outlet **25** of chamber **17** they will be at a temperature of 1450° K. as previously described. The fumes are then passed into a steam powerhouse **47**.

While several embodiments of the invention have been described by way of example, it will be understod that it is not limited to such embodiment, but it is intended that it shall cover all variations thereof that may be apparent to those skilled in the art.

We claim:

1. A heat exchanger comprising an exchange cham-

ber, a vertical partition extending upwardly from the bottom of said chamber to a point short of the top of said chamber so as to divide said chamber into two adjacent compartments and an upper portion and to provide at the top of said partition an overflow from one compartment to the other, a liquid heat carrier at one temperature contained in said one compartment, means located in the bottom portion of said one compartment for introducing gas at another temperature different from that of the liquid heat carrier into the lower portion of said liquid heat carrier so that it bubbles upwardly through the liquid and is discharged through the surface of the latter into said upper portion of said chamber, said liquid heat carrier being in such quantity in said one compartment that when atomized by the gas passing therethrough it will be caused to pass over said overflow into said other compartment, means for withdrawing the temperature changed gas from the upper portion of said chamber, a second exchange chamber having a vertical partition extending upwardly from the bottom thereof to a point short of its top so as to divide said second chamber into two adjacent compartments and an upper portion, and to provide at the top of said partition on overflow from one compartment to the other, a liquid heat carrier at a given temperature contained in said one compartment of said second chamber, means located in the bottom portion of said one compartment of said second chamber for introducing gas at another temperature different from said given temperature into the lower portion of the liquid heat carrier in said second chamber so that it bubbles upwardly through the liquid and is discharged through the surface of the latter into said upper portion of the second chamber, said liquid carrier being in such quantity in said one compartment of said second chamber that when atomized by the gas passing therethrough it will be caused to pass over the overflow of such one compartment and into said other compartment of said second chamber, means for withdrawing the temperature changed gas from the upper portion of said second chamber, and means bringing said one compartment of said first chamber into communication with said other compartment of said second chamber, and bringing said other compartment of said first chamber into communication with said first compartment of said second chamber, said communicating means supplying liquid heat carrier at said one temperature into said one compartment of said first chamber and supplying liquid heat carrier at said given temperature into said one compartment of said second chamber.

2. A heat exchanger as defined in claim **1**, in which said two compartments of said first and second chambers, and said liquid heat carrier supplying means form part of a closed circuit for the liquid heat carrier, and in which the bubbling action of the gas in said one compartment of said first and second chambers causes the circulation of the liquid heat carrier through said compartments and supplying means.

3. A heat exchanger as defined in claim **1**, including means for conducting the gas withdrawn from the upper portion of said first chamber to the gas introducing means in the bottom portion of said one compartment of said second chamber, and means for heating the gas in its passage through such gas conducting means.

4. A heat exchanger as defined in claim **1**, in which said heat exchanger is provided with one liquid heat carrier and in which said communication means is constructed and arranged to enable such one liquid heat carrier to flow from said other compartment of said first chamber to said one compartment of said second chamber, and from said other compartment of said second chamber to said one compartment of said first chamber.

5. A heat exchanger as defined in claim **4**, in which said gas introducing means in the one compartment of said first chamber supplies gas at a different pressure than said gas introducing means in the one compartment of said second chamber, and in which said first and second chambers are located at different heights, and said connecting and supplying means form columns of liquids compensating for the differences in pressure of the gas introduced into said one compartments.

6. A heat exchanger as defined in claim **1**, in which said heater exchanger is provided with two different liquid heat carriers, the first liquid heat carrier in said one compartment of said first chamber being of a different density than and immiscible with the second liquid heat carrier in said one compartment of said second chamber, and in which said liquid heat carrier supplying means comprises an intermediate heat exchange chamber having upper and lower end portions, means for conducting the first liquid heat carrier from said other compartment of said first chamber into one of said end portions of said intermediate chamber, and for conducting such first liquid heat carrier from the other of said end portions of said intermediate chamber into said one compartment of said first chamber, and means for conducting the second liquid heat carrier from said other compartment of said second chamber into said other end portion of said intermediate chamber, and for conducting such second liquid heat carrier from said one end portion of said intermediate chamber into said one compartment of said second chamber, whereby said two liquid heat carriers are brought into counter-current contact in said intermediate chamber to effect a heat exchange therebetween.

7. A heat exchanger as defined in claim **1**, including a third exchange chamber associated with said first mentioned exchange chamber and a fourth exchange chamber associated with said second exchange chamber, said third and fourth chambers each having a vertical partition extending upwardly from the bottom thereof to a point short of its top so as to divide such chamber into two adjacent compartments and an upper portion, and to provide at the top of said partition an overflow from one compartment to the other, a liquid carrier contained in said one compartment of said third and fourth chambers, means located in the bottom portions of said one compartment of said third and fourth chambers for introducing gas into the lower portions of the liquid heat carrier in said third and fourth chambers so that it bubbles upwardly through the liquid in each and is discharged through the surfaces thereof into the upper portions of said third and fourth chambers, said liquid carrier being in such quantity in said one compartments of said third and fourth chambers that when atomized by the gas passing therethrough it will be caused to pass over the overflows of such one compartments and into said other compartments of said third and fourth chambers, means for withdrawing the gas from the upper portions of said third and fourth chambers, said gas withdrawing means of said first chamber being connected to said gas introducing means of said third chamber to cause the temperature changed gas in said first chamber to be bubbled through the liquid carrier in said third chamber, and said gas withdrawing means of said fourth chamber being connected to said gas introducing means of said second chamber to cause the temperature changed gas in said fourth chamber to be bubbled through the liquid carrier in said second chamber, first connecting means enabling the liquid heat carrier discharged into said other compartment of said third chamber to flow into said one compartment of said fourth chamber, and second connecting means enabling the liquid heat carrier discharged into said other compartment of said fourth chamber to flow into said one compartment of said third chamber.

8. A heat exchanger as defined in claim **7**, including means connecting said gas withdrawing means of said third chamber to said gas introducing means of said fourth chamber to cause the temperature changed gas in said third chamber to be bubbled through the liquid carrier in said fourth chamber, said connecting means including means for heating the gas delivered from said third chamber to said fourth chamber.

References Cited

UNITED STATES PATENTS

1,905,185	4/1933	Morris	165—107 X
2,025,695	12/1935	Stewart	126—360 (A) X
2,064,850	12/1936	Beran	261—16
2,536,608	1/1951	Kemp	126—360 (A)
2,607,661	8/1952	See	126—360 (A) X
3,054,602	9/1962	Proudman	261—124 X
3,319,400	5/1967	Wilson et al.	261—22 X

FOREIGN PATENTS

507,066	6/1922	Germany.

TIM R. MILES, Primary Examiner

U.S. Cl. X.R.

261—18 B, 151, 16, 77, 124; 165—106, 108; 122—31 R