# United States Patent [19]

**Small et al.**

[11] **3,739,841**

[45] **June 19, 1973**


[54] **INDIRECT HEAT TRANSFER APPARATUS**


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[52] **U.S. Cl.** ..... **165/146**

[51] **Int. Cl.** ..... **F28b 1/06**

[58] **Field of Search** ..... 165/164, 146



[56] **References Cited**

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*Primary Examiner*—Edward G. Favors

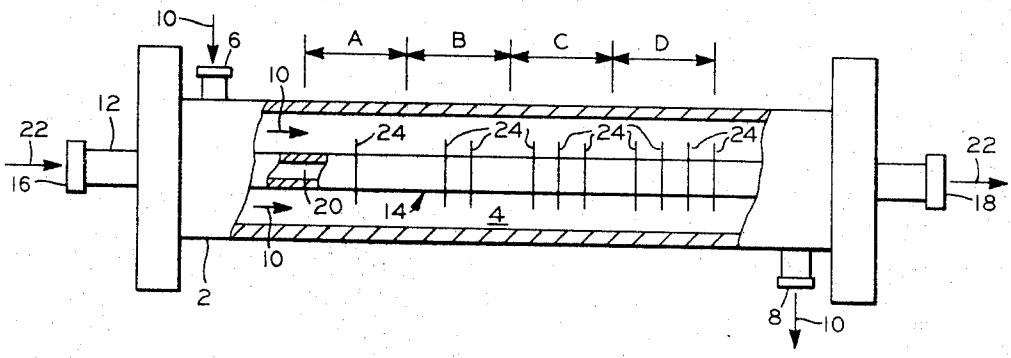
*Attorney*—Young & Quigg



[57] **ABSTRACT**

An indirect heat transfer apparatus has a second conduit extending through a first conduit with heat transfer members on the outer surface of the second conduit. The total surface area of the heat transfer members per unit length of the second conduit changes for altering the incremental heat transfer rate between first and second materials flowing through their respective first and second conduits.


**3 Claims, 3 Drawing Figures**



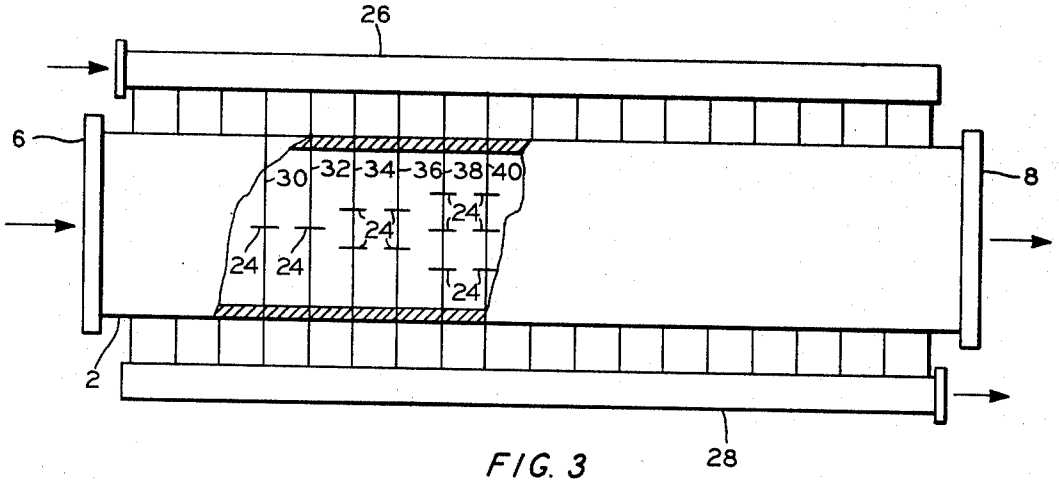



FIG. 3

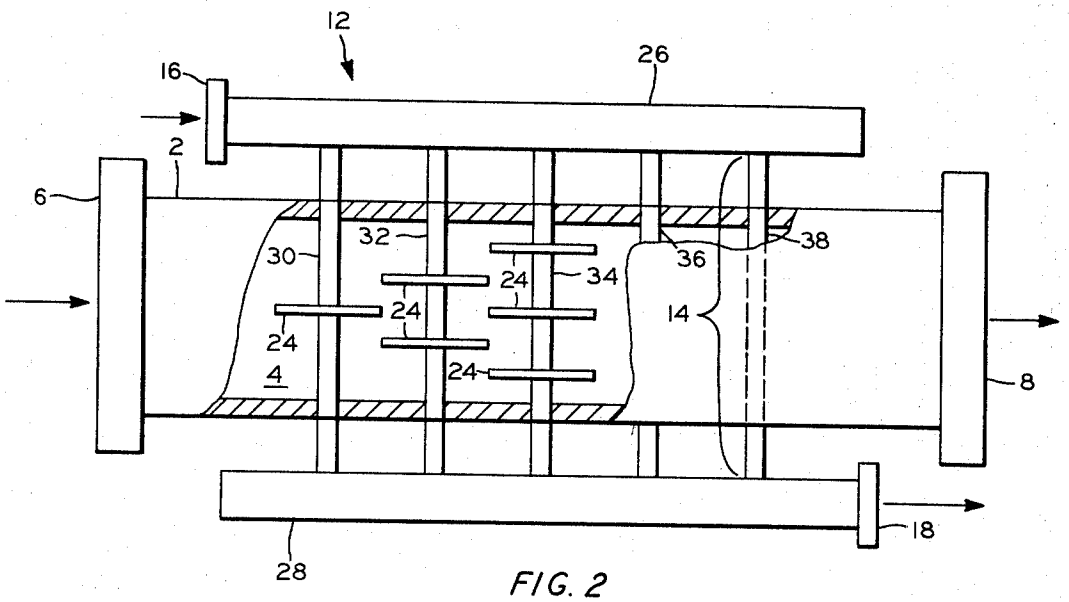



FIG. 2

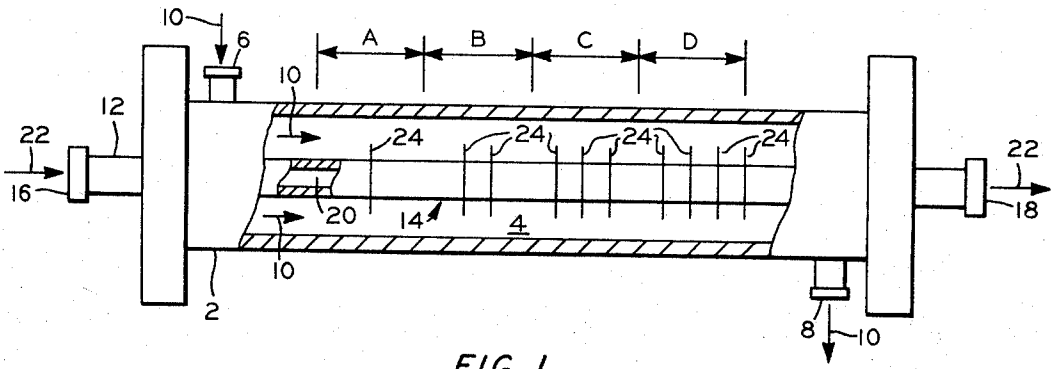



FIG. 1

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# INDIRECT HEAT TRANSFER APPARATUS

In a multiplicity of refining, material handling, and other chemical functions, it is desirable to heat or cool one material by indirect heat exchange with another material at a uniform, carefully controlled rate. Heretofore utilized apparatus employed heat transfer members on one of the material-carrying conduits to increase the rate of heat exchange between the two materials. With some materials, an abrupt change in temperature during the heating or cooling process will detrimentally alter the characteristics of that material. This is particularly true with endothermic chemical reactions conducted at a high temperature level such as dehydrogenation of paraffinic hydrocarbons. In order to avoid damage to these sensitive materials, it then becomes necessary to pass the materials through a plurality of heat exchangers and incrementally increase or decrease the temperature of the heating or cooling material supplied each successive heat exchanger. This plurality of heat exchanger systems represents large expenditures of time, labor, equipment, and maintenance for the construction, operation, and repair thereof.

This invention therefore lies in uniquely providing an extended heat exchange surface on a second conduit within a first conduit of an indirect heat exchanger for altering the incremental heat transfer rate between first and second materials flowing through their respective first and second conduits.

Other aspects, objects, and advantages of the present invention will become apparent from a study of the disclosure, the appended claims, and the drawing.

The drawings are diagrammatic views of the first and second conduits of a heat exchanger and the heat exchange members. FIG. 1 shows one embodiment of a heat exchanger of this invention with heat exchange members thereon, FIG. 2 shows another embodiment of a heat exchanger of this invention with heat exchange members thereon, and FIG. 3 shows another embodiment of the heat exchange members of FIG. 2.

Referring to FIG. 1, a first conduit 2 is provided for passing a first material through a chamber 4 extending therethrough. The first conduit 2 has an inlet end 6 and an outlet end 8 both in communication with the chamber 4 for passing a first material through the chamber 4 along a pathway represented by arrows 10. A second conduit 12 is associated with the first conduit 2 with a heat exchange portion 14 of said second conduit 12 being positioned within the chamber 4 of the first conduit. The second conduit 12 has an inlet end 16 and an outlet end 18 both in communication with a chamber 20 of said second conduit 12 for passing a second material through the chamber 20 along a pathway represented by arrows 22.

A plurality of heat transfer members 24 are positioned at spaced-apart locations relative one to the other on the outer surface of the second conduit portion 14. These heat transfer members 24 are protrusions extending outwardly from the second conduit and can be of various configurations such as fins, plates, rods, for example, and are well known in the art. These heat transfer members 24 are positioned such that the total effective heat transfer surface area for each unit length A, B, C, or D of the second conduit 12, for example, is changing, for example, in relation to the incremental increase of distance said unit length is positioned from the inlet end 6 of the first conduit 2.



Referring in FIG. 2, the indirect heat exchanger is of different construction. In this embodiment, the second conduit 12 comprises an inlet header 26, an outlet header 28, and a plurality of second conduit portions 30,32,34,36 and 38, for example, extending transversely through the chamber 4 of the first conduit 2 generally perpendicularly to the direction of flow of the first material through the first conduit 2. The portion 14 of each second conduit portion 30,32,34,36,38 within the chamber of the first conduit in this embodiment forms a separate unit length of the second conduit 12 for locating the heat transfer members 24 thereon, as set forth above. Each of these second conduit portions 30,32,34,36,38 are spaced one from the other in chamber 4 along the length of the first conduit 2 with each second conduit portion 30,32,34,36,38 being attached to and in communication with the inlet and outlet headers 26,28.

FIG. 3 shows another embodiment of the heat exchanger shown in FIG. 2 and described above. In this embodiment, a unit length of the second conduit portion is formed of a plurality of adjacently positioned second conduit portions, here shown as 30,32 and 34,36, and 38,40, for example. This embodiment has been found to be particularly adapted to an exchanger wherein the temperature difference between the first and second materials as measured at their respective inlet ends 6,26 is relatively narrow.

The placement of the heat transfer members, the number of members utilized, and the surface area of each member is dependent upon the types of the materials therethrough and thereover, conductivity of the members, the differences in temperatures between the first and second materials, and other factors.

The placement, number, and type of heat transfer members can be calculated by one skilled in the art of thermodynamics and heat transfer once the variables of the fluids to be utilized are established.

In the operation of the cocurrent flow heat transfer apparatus shown in FIG. 1, the cooling or heating material can be passed through either the first or second conduits 2,12 depending on the physical conditions, volumes of each material, and other factors affecting heat transfer, as is known in the art. As a heating or cooling fluid progressively passes through the heat transfer apparatus, said material encounters a greater number of heat transfer members 24; thereby the incremental heat transfer per unit length is maintained at a more uniform level owing to the fact that, as the temperature of said fluid changes, the surface area of said heat transfer members is changed to compensate for said temperature changes.

The heat exchangers shown in FIGS. 2 and 3 are particularly adapted to maintain the temperature of each second conduit portion 30,32,34,36 or 38, for example, at substantially one uniform or particular temperature profile. This is accomplished by changing the total area of the heat transfer members per unit length as set forth above thereby compensating for the change of temperature of the first material passing through the heat transfer apparatus. As described above, the embodiment shown in FIGS. 2 and 3 can also be utilized for maintaining the temperature of the first material.

It should be understood that the materials can be gases, liquids, or solids within liquids or gases, or any combination thereof. The term heat exchanger used herein is meant to mean any indirect heat transfer ap-

paratus, such as heat exchangers employed to heat or cool process fluids in the absence of chemical reaction and, particularly, heat exchangers employed in the conducting of strongly endothermic chemical reactions (dehydrogenation, cracking, etc.) and strongly exothermic chemical reactions (polymerization, isomerization, alkylation, etc.) The total surface area of each transfer member of the apparatus can be different relative one to the other. The conduits can also be angularly disposed one to the other, have heat transfer members that are internal or external, be a single or multi-pass exchanger and be arranged for countercurrent flow without departing from the scope of this invention. In multi-pass exchangers, each pass can be identical to subsequent passes or each pass can differ in the arrangement of heat exchange surfaces.

One example of an apparatus similar to that shown in FIG. 3 of this invention is as follows:

EXAMPLE I

| | |
|---|---|
| Cross-sectional dimensions of first conduit (2) | 10 ft. by 10 ft. square |
| I.D. of second conduit portion (30–40) | 2 inches |
| O.D. of second conduit portion (30–40) | 2.25 inches |
| Length of each second conduit portion (30–40) | 10 ft. |
| Number of each second conduit portions (14) | 6 |
| Spacing between second conduit portions (14) | 2 in. |
| First material type | Flue gases from combustion of natural gas |
| Second material type | Normal butane |
| First fluid temperature | 1200°F entrance, 1150°F exit |
| Second fluid temperature | 1050°F entrance, 1125°F exit |
| Heat exchange members | ½ in. fins – Steel, surface area per fin = 180 in.² approx. |

| Conduit Portion | Number of Fins |
|---|---|
| 30 | 1 |
| 32 | 1 |
| 34 | 2 |
| 36 | 2 |
| 38 | 3 |
| 40 | 3 |

Other modifications and alterations of this invention will become apparent to those skilled in the art from the foregoing discussion, example, and accompanying drawing, and it should be understood that this invention is not to be unduly limited thereto.

What is claimed is:

**1.** An indirect heat transfer apparatus for maintaining a preselected heat transfer between first and second materials flowing therethrough, comprising:

a first conduit having a chamber and an inlet and an outlet end for the passage of a first material through said chamber;

a second conduit having a chamber and inlet and outlet ends with a portion of said second conduit being positioned within the chamber of the first conduit for the passage of a second material through said second conduit chamber; and

means for controlling the temperature of the second material and maintaining said material on a preselected temperature profile during the passage of the second material through the second conduit and during exothermic chemical reactions with the second conduit, said means comprising a plurality of heat transfer members at spaced-apart locations relative one to the other on the outer surface of the second conduit portion within the chamber of the first conduit with the total surface area of the heat transfer members for each unit length of the second conduit changing in relation to the incremental increase of distance said unit length is positioned from the inlet end of the first conduit and the temperature of the second material at each respective unit length.

**2.** An apparatus, as set forth in claim **1**, wherein the second conduit comprises:

an inlet header attached to the inlet end of the second conduit;

an outlet header attached to the outlet end of the second conduit;

a plurality of second conduit portions extending traversely through the chamber of the first conduit generally perpendicularly to the direction of flow of the first material through said first conduit with the portion of each second conduit portion within the chamber of the first conduit forming a separate unit length of the second conduit, being spaced one from the other along the length of the first conduit, and with each second conduit portion being attached to and in communication with the inlet and outlet headers.

**3.** An apparatus, as set forth in claim **1**, wherein the second conduit comprises:

an inlet header attached to the inlet end of the second conduit, an outlet header attached to the outlet end of the second conduit, a plurality of second conduit portions each extending traversely through the chamber of the first conduit substantially perpendicularly to the direction of flow of the first material through the first conduit with a plurality of adjacently positioned second conduit portions within the chamber of the first conduit forming a separate unit length of the second conduit, said second conduit portions within the chamber of the first conduit each being spaced one from the other, each unit length being positioned along the length of the first conduit, and with each second conduit portion being attached to and in communication with the inlet and outlet headers.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

**Patent No.** 3,739,841 William M. Small et al **Dated:** June 19, 1973

It is certified that error appears in the above-identified patent and tha said Letters Patent are hereby corrected as shown below:

Column 4, line 8, "with" should read --- within ---.

Signed and sealed this 19th day of February 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents