Nov. 19, 1957 H. VAN N. SCHENCK, JR 2,813,700

EVEN DISTRIBUTION HEADER SYSTEM

Filed Aug. 20, 1954

FIG. 1

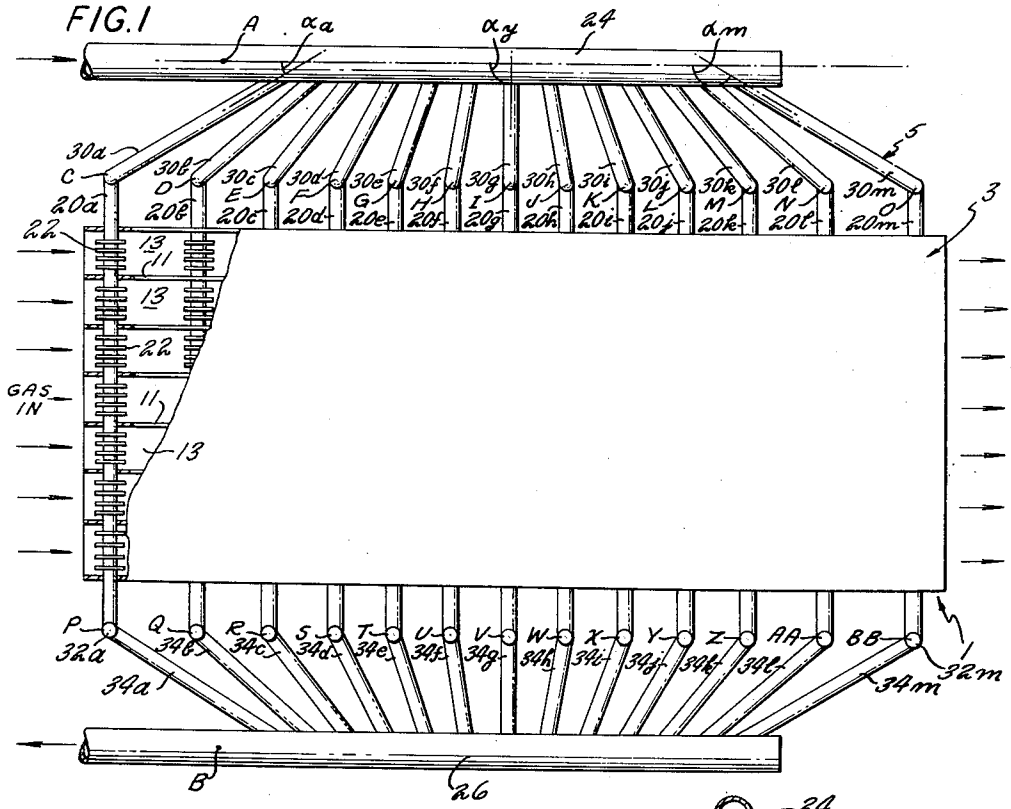
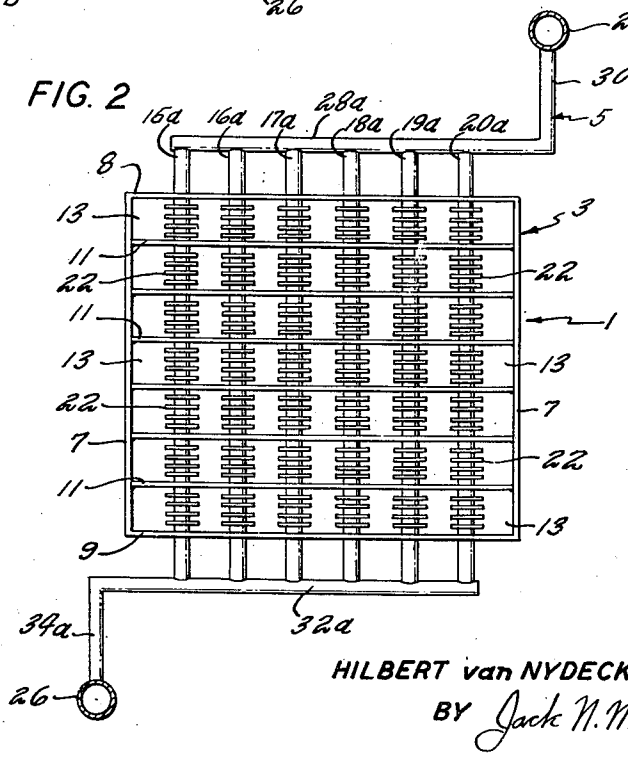


FIG. 2



INVENTOR
HILBERT van NYDECK SCHENCK JR.
BY Jack N. McCarthy
AGENT

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EVEN DISTRIBUTION HEADER SYSTEM

Hilbert Van Nydeck Schenck, Jr., East Hartford, Conn., assignor to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware

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14 Claims. (Cl. 257—241)

This invention relates to header systems in which fluid is to be distributed from a main duct, or header, into a multiplicity of smaller ducts, or tubes, and more particularly to systems in which this distribution must be carefully controlled such that each small duct or tube receives a specified fraction of the total flow in the main duct or header.

An object of this invention is to provide a new and novel method of providing a variable pressure drop in the form of a varying angularity between the main duct and the small tubes. The fluid distribution in a main header with a multiple branch system will be governed by the total or irreversible pressure drop of the fluid as it traverses each possible path in the system. Only when the total pressure drop through any possible path is equal to the total pressure drop through any other possible path will the flow distribution be stable. Under any other circumstance, the fluid flowing through the path of high pressure drop will tend to be impeded by this high resistance and the flow rate will drop. The fluid flowing through the path of low pressure will be accelerated and the flow rate over this path will increase. These processes will occur over all paths until stability, that is, equal pressure drops over all paths, is achieved. Therefore, control of the total pressure loss or drop over all possible paths is necessary to insure that the main header flow distributes the fluid to the branches in a prescribed and desired manner.

Another object of this invention is to provide a simpler and more effective method of controlling the total pressure loss or drop through each tube. When the fluid turns from the main header into a small tube having a very sharp angle, the total pressure drop due to turning is large and, when the lead-off angle is very slight, so that the fluid continues in almost the same direction in the small tube as in the main header, the total pressure drop due to turning is slight.

In an actual header system, the fluid will lose pressure as it traverses the main header, that is, feeding the many small tubes. Thus the fluid at the entrance to the main header will have a higher total pressure than the fluid further down along the header. Unless some secondary pressure drop inducing mechanism is added to the system, more of the fluid will tend to turn into the branches near the entrance to the main header pipe, and less and less fluid will turn into the tubes at the farther end from the entrance. This is a generally unfavorable situation since in most fluid distribution systems found in heat exchanger headers, it is desired that all branch tubes receive equal flows of fluid.

The unfavorable distribution due to friction in the main header pipe can be corrected by angling each small tube by a specific amount. These tubes near the entrance to the main header will have sharp angles and high total pressure drops, while those farthest from the main header entrance will have shallow angles and low total pressure drops. Thus the sum of friction pressure drop and turning pressure drop into each small tube will be the same for all paths and the flow will be properly distributed.

By manipulating the variation of lead-off angle, other distribution patterns could be obtained. That is, more fluid can be sent into the branches nearest the main pipe entrance, or more fluid can be sent into the farther branches if this were desired.

For a more complete understanding of the invention, reference should be had to the drawings in which:

Figure 1 is a side view, partially in section, of a fluid-to-gas heat exchanger having angled branch pipes at entrance and exit.

Figure 2 is an end view of Fig. 1 as seen from the direction of gas flow.

Referring to the figures, the invention is shown embodied in a fluid-to-gas heat exchanger **1**. This heat exchanger is a finned-tube type of one-pass and cross-flow arrangement, and comprises a main gas flow duct or chamber **3** and a fluid header system **5**. The gas flow duct or chamber **3** is formed rectangular in shape having sides **7**, top **8** and bottom **9**. The sides **7** are also connected by intermediate plates **11** which divide the gas flow duct or chamber **3** into a plurality of passageways or smaller chambers **13**. Extending through the gas flow duct from top to bottom are a plurality of fluid flow tubes. These tubes are arranged in six banks, **15**, **16**, **17**, **18**, **19** and **20**, with thirteen rows, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *l* and *m*, in each bank. The tubes are fixed to the gas flow duct and have fins **22** affixed thereto in the passageways **13** formed by the intermediate plates **11**.

The fluid header system **5** has a main inlet header **24** and a main outlet header **26**. Each row of fluid flow tubes **15** through **20** is connected at its upper end by an inlet collector tube **28**. Fluid inlet header **24** is attached to each inlet connector tube **28** by an inlet header adapter **30**. (In the specification and figures these inlet connector tubes **28** and header adapters **30** have the row letter affixed when a particular inlet connector tube **28** or header adapter **30** is referred to. For example the first header connector tube is **28***a* and the header adapter connecting it to the inlet header **24** is **30***a*.) Each row of fluid flow tubes **15** through **20** is connected at its lower end by an outlet collector tube **32**. Fluid outlet header **26** is attached to each outlet collector tube **32** by a header adapter **34**. (In the specification and figures these outlet collector tubes **32** and header adapters **34** have the row letter affixed when a particular outlet collector tube **32** or header adapter **34** is referred to.)

In this heat exchanger arrangement the gas passing therethrough enters at the left of gas flow duct or chamber **3** as viewed in Fig. 1 and passes over the surfaces of intermediate plates **11** and fins **22** of the fluid flow tubes therein as well as around the fluid flow tubes themselves. This gas flow exits from the other end of the gas flow duct or chamber **3**. The flow of gas may be directed into the heat exchanger gas flow duct or chamber **3** in any manner desired and it may be collected or exhausted at the other end by any desirable means. The fluid passing through the fluid header system **5** enters the open end of the main inlet header **24** and passes through the header adapters **30** to the inlet connector tubes **28**. From the inlet connector tubes **28** the fluid flows through each of the fluid flow tubes to the outlet collector tubes **32**. The fluid is then directed to the main outlet header **26** through header adapters **34**.

If equal flow in all passages through the heat exchanger is desired, each element of fluid entering the open end of the main inlet header **24** at point A must undergo the same total pressure loss or drop through the heat exchanger **1** to the outlet of the main outlet header **26** at point B. It can be seen that each element of fluid passing from the juncture of any inlet connector tube **28** and inlet header adapter **30** traverses the same length of passageway and makes the same number of turns to the juncture

of its cooperating outlet collector tube **32** and outlet header adapter **34**. Thus, if equal flow over all other paths is established, the additional flow over these paths will not unbalance the total flow. These other paths consist of (1*a*) the paths from point A in the main inlet header **24** to each of the junctures C through O of the inlet connector tubes and inlet header adapters, and (2*a*) the paths from the junctures P through BB of the outlet collector tubes and outlet header adapters to point B in the main outlet header **26**.

Taking the paths referred to in item (1*a*) above, if these pressure drops all remained the same the following relationship would follow:

(*a*) $(\Delta pA\text{–}C)=(\Delta pA\text{–}D)=(\Delta pA\text{–}E)\ .\ .\ .=(\Delta pA\text{–}O)$

As the fluid traverses the main inlet header **24**, it loses total pressure due to friction. The fluid that turns into a header adapter **30** will also have a total pressure loss, however this is proportionate to the angle of turn which the header adapter forms with the main inlet header **24**. This means that the total pressure loss or drop along a path from A to any juncture point C through O can be divided into two main separate parts. Substituting these two separate losses or drops for the loss or drop in formulae (*a*) we have:

(*b*) (Δp friction $A\text{–}C+\Delta p$ turning $A\text{–}C$)=(Δp friction $A\text{–}D+\Delta p$ turning $A\text{–}D$) . . .=(Δp friction $A\text{–}O+\Delta p$ turning $A\text{–}O$)

As viewed in Fig. 1 it can be seen that the distance from A to the point where each successive inlet header adapter connects to the main inlet header **24** increases in length thereby having an increasing total pressure loss or drop due to friction between these various points. To bring this pressure loss or drop to a common value when the flow is distributed equally over all paths, another pressure loss or drop has to be added. Since the pressure losses or drops due to friction all increase, the pressure losses or drops to be added must all decrease from A–C to A–O. A proper angular position of inlet header adapters **30***a* through **30***m* will provide this additional pressure loss or drop.

Using rows *a*, *g* and *m* as examples, the Δp friction from A to **30***a* is the smallest, the Δp friction from A to **30***g* is of a medium value, and the Δp friction from A to **30***m* is the largest. To compensate for this the Δp turning A–C in view of the acute angle αa is the highest, the Δp turning A–I is of a medium value, and the Δp turning A–O in view of the large angle αm is the lowest. It can be seen here that (1) a low and high value are added (2) two medium values are added and (3) a high and low value are added tending to equalize the pressure drop. While the differences in length of the header adapters will produce a further unbalance, this effect can be overcome by simply changing the angularity of the header adapters slightly.

The paths referred to in item (2*a*) above operate in an identical manner to the paths in item (1*a*) except the flow is reversed.

The proper angular position of each of the inlet header adapters **30** to the main inlet header **24** and the proper angular position of each of the outlet header adapters **34** to the main outlet header **26** can be (1) figured analytically or (2) actually measured until the pressure drop from A to all the junctures C through O are equal when the desired flow distribution is obtained.

In determining the proper angular position of the header adapters to the main headers the following method can be used: (1) a header system may be built consisting of a main header and a plurality of smaller tubes extending therefrom; (2) a fluid flow can be directed into the main header and the flow in each of the smaller tubes measured; (3) the angularity of each small tube may then be varied with respect to the main header until like flows are obtained. In changing the angularity of the smaller tubes any means desired may be used. For example, if the tubes are brazed or welded to the main header, in order to change the angularity of the tubes to the main header the tubes may be removed and rebrazed or rewelded at a different angular position.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

I claim:

1. In combination, an elongated main header having a fluid inlet at one end, and a plurality of header adapters connected to said main header at spaced locations along the length of the latter, said header adapters being connected to said main header at different angles to produce different pressure drops in a fluid passing therebetween.

2. In combination, a main header, and a plurality of header adapters in a row, said header adapters being connected to said main header at different angles to produce different pressure drops in a fluid passing therebetween, each header adapter nearer one end of said row forming an angle with said header of less than 90°, each header adapter nearer the other end of said row forming a corresponding angle with said header of more than 90°.

3. In combination, a main inlet header, said main inlet header having an open inlet end, a plurality of inlet header adapters, said inlet header adapters being connected to said main inlet header along a length of said main inlet header, said inlet header adapters being connected to said main inlet header at different angles to produce a like pressure drop from the open inlet end of said main inlet header to the downstream end of each inlet header adapter with equal flow in all inlet header adapters.

4. In combination, a main inlet header, a plurality of inlet header adapters, said inlet header adapters being connected at their upstream ends to said main inlet header at different angles to produce different pressure drops in a fluid entering each inlet header adapter, said inlet header adapters being connected at their downstream ends to fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, a main outlet header, a plurality of outlet header adapters, said outlet header adapters being connected at their downstream ends to said main outlet header at different angles to produce different pressure drops in a fluid leaving each outlet header adapter, said outlet header adapters being connected at their upstream ends each to the free ends of the fluid flow tubes.

5. In combination, a main inlet header, said main inlet header having an open inlet end, a plurality of inlet header adapters, said inlet header adapters being connected to said main inlet header along a length of said main inlet header and extending from said main inlet header in a single plane, said inlet header adapters being connected to said main inlet header at different angles to produce a like pressure drop from the open inlet end of said main inlet header to the downstream end of each inlet header adapter with an equal distribution of flow in all inlet header adapters.

6. In combination, a main inlet header, a plurality of inlet header adapters, said inlet header adapters being connected at their upstream ends to said main inlet header at different angles to produce different pressure drops in a fluid entering each inlet header adapter, said inlet header adapters being connected at their downstream ends each to an inlet connector tube, the inlet connector tubes each being connected to a set of fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, a plurality of outlet collector tubes, an outlet collector tube being connected to the other end of each set of fluid flow tubes connected to an inlet connector tube, a main outlet header, a plurality of outlet header adapters, said outlet header adapters being connected at their downstream ends to said main outlet header at different angles

to produce different pressure drops in a fluid leaving each outlet header adapter, said outlet header adapters being connected at their upstream ends each to an outlet collector tube.

7. In combination, a main inlet header having an open end, a plurality of inlet header adapters, said inlet header adapters being connected at their upstream ends to said main inlet header at different angles to produce a like pressure drop from the open end of said main inlet header to the downstream end of each inlet header adapter, said inlet header adapters being connected at their downstream ends to fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, a main outlet header having an open end, a plurality of outlet header adapters, said outlet header adapters being connected at their downstream ends to said main outlet header at different angles to produce a like pressure drop from the upstream end of each outlet header adapter to the open end of said main outlet header, said outlet header adapters being connected at their upstream ends each to the free end of one of the fluid flow tubes.

8. In combination, a main inlet header having an open end, a plurality of inlet header adapters, said inlet header adapters being connected at their upstream ends to said main inlet header at different angles to produce a like pressure drop from the open end of said main inlet header to the downstream end of each inlet header adapter, said inlet header adapters being connected at their downstream ends to fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, said gas flow chamber being divided into smaller chambers, a main outlet header having an open end, a plurality of outlet header adapters, said outlet header adapters being connected at their downstream ends to said main outlet header at different angles to produce a like pressure drop from the upstream end of each outlet header adapter to the open end of said main outlet header, said outlet header adapters being connected at their upstream ends each to the free end of one of the fluid flow tubes.

9. In combination, a main inlet header having an open end and a closed end, a plurality of inlet header adapters, said inlet header adapters being connected at one end to said main inlet header at different angles, each inlet header adapter nearer said open end of said main inlet header forming an angle with said header of less than 90°, each inlet header adapter nearer said closed end of said main inlet header forming a corresponding angle with said header of more than 90°, said inlet header adapters being connected at their other ends each to an inlet connector tube, said inlet connector tubes each being connected to a set of fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, a plurality of outlet collector tubes, an outlet collector tube being connected to the other end of each set of fluid flow tubes connected to an inlet connector tube, a main outlet header having an open end, a plurality of outlet header adapters, said outlet header adapters being connected at one end to said main outlet header at different angles, said outlet header adapters being connected at their other ends each to an outlet collector tube, the angularity of the inlet and outlet header adapters being arranged to produce a like pressure drop from the open end of said main inlet header to the open end of said main outlet header through any path.

10. In combination, a main fluid inlet header having an open end, a plurality of inlet header adapters, said inlet header adapters being connected at one end to said main inlet header at different angles to produce a like pressure drop from the open end of said main inlet header to the downstream end of each inlet header adapter, said inlet header adapters being connected at their downstream ends to fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, said gas flow chamber being divided into smaller chambers, a main fluid outlet header having an open end, a plurality of outlet header adapters, said outlet header adapters being connected at one end to said main outlet header at different angles to produce a like pressure drop from the upstream end of each outlet header adapter to the open end of said main outlet header, said outlet header adapters being connected at their upstream ends each to the free end of one of the fluid flow tubes, each inlet header adapter nearer the open end of said main inlet header forming an angle with the latter of less than 90°, each inlet header adapter nearer the other end of said main inlet header forming with the latter a corresponding angle of more than 90°, the angle formed between each inlet header adapter and its connected inlet header being measured from the upstream portion of said connected inlet header.

11. In combination, a main inlet header having an open end, a plurality of inlet header adapters, said inlet header adapters being connected at one end to said main inlet header at different angles to produce a like pressure drop from the open end of said main inlet header to the downstream end of each inlet header adapter, said inlet header adapters being connected at their downstream ends to fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, said gas flow chamber being divided into smaller chambers, a main outlet header having an open end, a plurality of outlet header adapters, said outlet header adapters being connected at one end to said main outlet header at different angles to produce a like pressure drop from the upstream end of each outlet header adapter to the open end of said main outlet header, said outlet header adapters being connected at their upstream ends each to the free end of one of the fluid flow tubes, each outlet header adapter nearer one end of said main outlet header forming an angle with the latter of less than 90°, each outlet header adapter nearer the other end of said main outlet header forming with the latter a corresponding angle of more than 90°, the angle formed between each outlet header adapter and its connected outlet header being measured from the upstream portion of said connected outlet header.

12. In combination, a main inlet header having an open end, a plurality of inlet header adapters, said inlet header adapters being connected at one end to said main inlet header at different angles to produce a like pressure drop from the open end of said main inlet header to the downstream end of each inlet header adapter, said inlet header adapters being connected at their downstream ends to fluid flow tubes, a gas flow chamber, said fluid flow tubes extending through said gas flow chamber, said gas flow chamber being divided into smaller chambers, a main outlet header having an open end, a plurality of outlet header adapters, said outlet header adapters being connected at their downstream ends to said main outlet header at different angles to produce a like pressure drop from the upstream end of each outlet header adapter to the open end of said main outlet header, said outlet header adapters being connected at their upstream ends each to the free end of one of the fluid flow tubes, each inlet header adapter nearer the open end of said main inlet header forming an angle of less than 90°, each inlet header adapter nearer the other end of said mean inlet header forming an angle of more than 90°, the angle that each inlet header adapter forms with said main inlet header being measured on the same side of said inlet header adapters, each outlet header adapter nearer the open end of said main outlet header forming an angle of less than 90°, each outlet header adapter nearer the other end of said main outlet header forming an angle of more than 90°, the angle that each outlet header adapter forms with said main outlet header being measured on the same side of said outlet header adapters.

13. A method of distributing a fluid flowing in a main pipe into a plurality of smaller tubes which consists of first, measuring the flow in each smaller tube, then, varying the angularity of each smaller tube with respect to the main pipe until like flows are obtained.

14. In combination, an elongated main header having a fluid inlet at one end thereof, a plurality of inlet header adapters having fluid connections to said main header at spaced locations along a length thereof, said adapters being connected to said main header at different angles to produce different pressure drops in a fluid passing therebetween, said angles being measured between said header adapters and an adjacent upstream portion of said main header.

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