Sept. 13, 1966 S. H. S. RAUB ETAL 3,272,260

CORROSION RESISTANT HEAT EXCHANGER

Filed Aug. 11, 1961 2 Sheets-Sheet 1

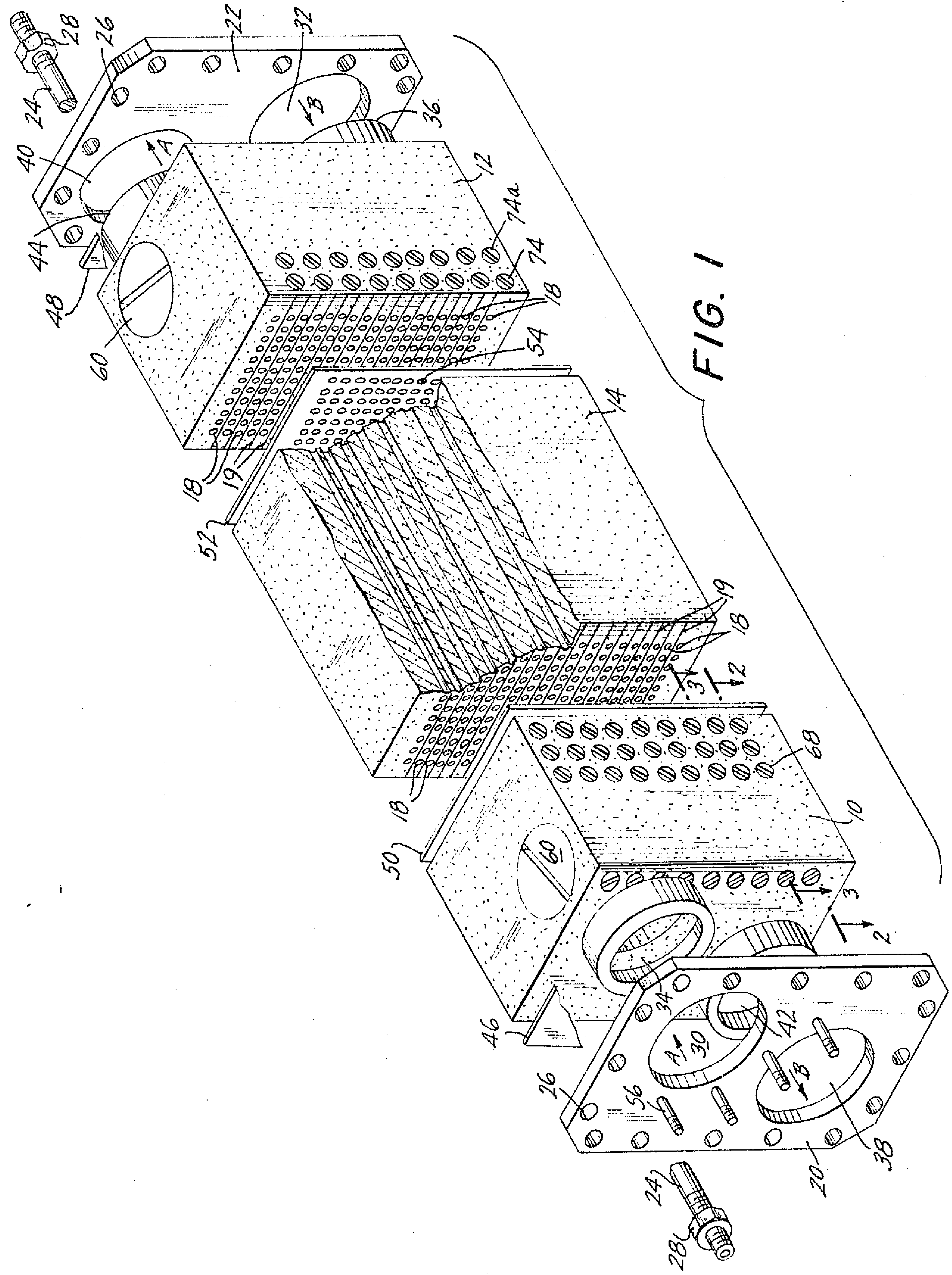

FIG. 1

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FIG. 2

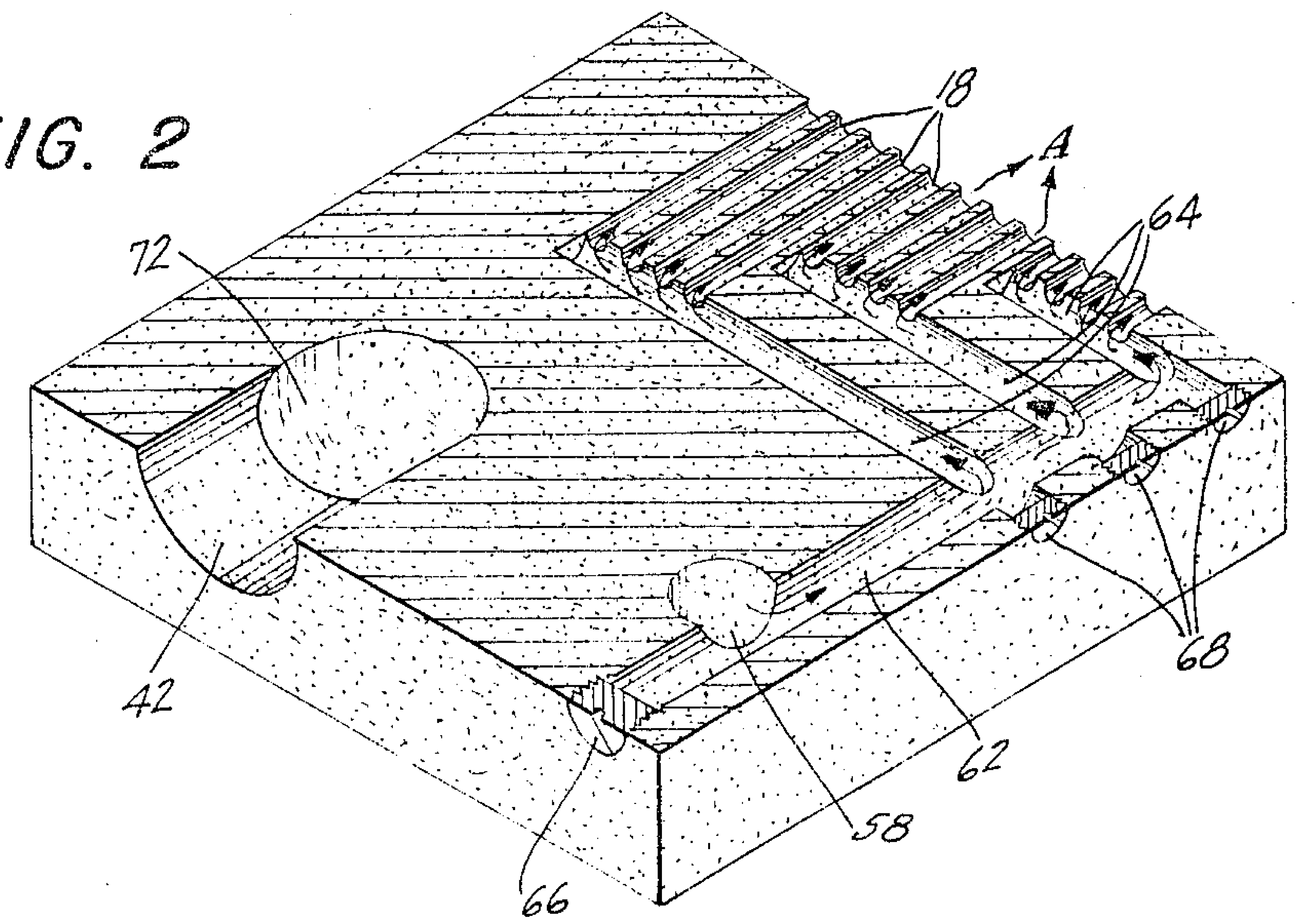
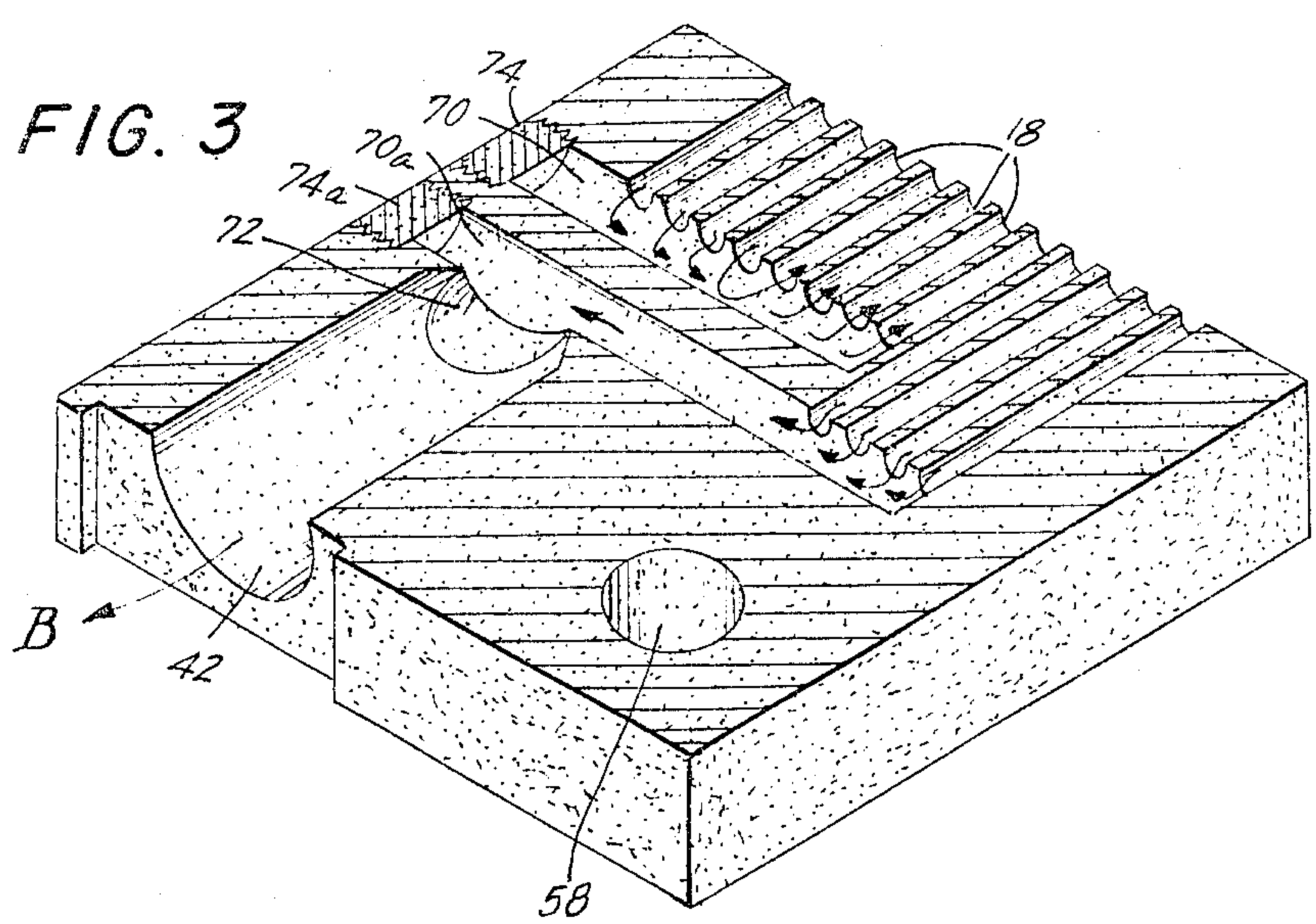


FIG. 3



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CORROSION RESISTANT HEAT EXCHANGER

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This invention relates to a corrosion resistant heat exchanger, and more particularly, to a heat exchanger of impervious graphite.

There are many industrial processes in which heat exchangers are used to transfer heat from one moving fluid to another moving fluid, the effect being to increase or decrease the temperature of any one fluid according to whether it enters the heat exchange system at a lower or at a higher temperature than that of the other fluid. Among the countless type of heat exchangers available, the most common are the plate type, the tube type, and the block type. Depending upon what fluids are to be involved, the heat exchangers may be made partially or totally of metal or graphite.

The principal object of this invention is to provide an improved heat exchanger of the block type which is fabricated from impervious graphite.

More specifically, an object of the invention is to provide a heat exchanger of the type described which may embody the excellent thermal efficiency of true counterflow design.

Another object of the invention is to provide a heat exchanger of the type described wherein the distance of travel of heat flow between the two fluids is constant thereby eliminating so called hot spots.

Still another object of the invention is to provide a heat exchanger of the type described wherein the total heat transfer area available may be easily varied over a wide range as desired both at the time of manufacture and subsequent thereto.

Broadly stated, the objects of the invention are accomplished by a heat exchanger which comprises in combination two headers fabricated from monolithic blocks of impervious graphite and which are separated usually by one or more blocks of monolithic impervious graphite. The headers and the blocks have drilled therein a plurality of horizontal corresponding passageways, the axes of which are all parallel. Each of the headers is provided with a fluid inlet and outlet and conduits which connect the inlets and outlets with the horizontal rows of passageways. Usually the conduits are so disposed that each of the fluids involved are conducted through alternate rows of passageways and preferably in a counter flow direction through the heat exchanger. However, if desired the two fluids involved may be diverted into an unequally divided number of rows of passageways.

The invention will be more readily understood by reference to the drawing wherein:

FIG. 1 is an exploded view, partially in section, of a heat exchanger which embodies the principles of the invention;

FIG. 2 is a view of the heat exchanger of FIG. 1 along the line 2—2 of FIG. 1; and

FIG. 3 is a view of the heat exchanger of FIG. 1 along the line 3—3 of FIG. 1.

While the heat exchanger shown comprises two headers separated by one block, it should be appreciated that the heat exchanger of the invention is not so limited and one way of varying the total heat transfer surface area of a heat exchanger embodying the principles of the invention is to provide a plurality of blocks in line instead of one, or no blocks at all since a considerable amount of heat transfer occurs in the headers themselves. This may be

done, of course, at the time the heat exchanger is originally assembled or at any later time.

Referring now to the drawing, and particularly FIG. 1, the heat exchanger shown comprises in combination two impervious graphite headers **10** and **12**, separated by an impervious graphite block **14**. Both the headers **10** and **12**, and the block **14** which originally were monolithic blocks of impervious graphite, have all been provided with a plurality of corresponding drilled passageways **18**, the axes of which are all parallel. In addition, in the preferred embodiment, the faces of the headers **10** and **12** and the faces of the center block **14** are all provided with horizontal machined grooves **19** which extend across the faces between each row of horizontal passageways **18**.

It should be understood that the words horizontal and vertical as used herein and in the appended claims refers to the heat exchanger as illustrated in the drawing. The heat exchanger of the invention may, of course, be installed where desired in any position, i.e., on its side, on one end, etc.

In a complete unit pressure plates **20** and **22** are provided at opposite ends of the heat exchanger. The plates **20** and **22** are tied together with a plurality of tie rods **24** which pass through apertures **26** provided in the plates **20** and **22**, and secured by nuts **28**. The pressure plates **20** and **22** respectively are provided with apertures **30** and **32** for the inlets **34** and **36** of headers **10** and **12** and apertures **38** and **40** for the outlets **42** and **44** of the headers **10** and **12**.

In order to protect the graphite headers, properly apertured pressure pads **46** and **48** are positioned between the pressure plates **20** and **22** and the headers **10** and **12**. Gaskets **50** and **52**, having apertures **54** which exactly correspond to the passageways **18**, are provided between block **14** and the headers **10** and **12**. In the event of faulty gasket sealing due to insufficient pressure on the gasket or a faulty gasket surface, the grooves **19** will prevent interpassage exchange of fluids by channelling the fluids to the periphery of the heat exchanger. In addition, the escape of the fluid at a particular groove **19** will act as a "tell-tale" to where the leakage is occurring with the heat exchanger. Threaded studs **56** may be provided on the pressure plates **20** and **22** for ease of connecting the heat exchanger into appropriate fluid lines.

As shown in FIGS. 2 and 3, the headers **10** and **12** are provided with a plurality of drilled conduits which taken together conduct the fluids designated as A and B in FIG. 1 from the inlets in the headers into alternate rows of drilled passageways **18** and collect the fluids A and B from the alternate rows of passageways **18** and channel them, as the case may be, into either a plurality of passes through the passageways **18** in the headers **10** and **12** and the block **14**, or into the outlets **42** and **44**. In the particular heat exchanger illustrated, fluid A is allowed to make a single pass through the entire exchanger and fluid B makes a total of three passes through the entire exchanger.

Prior to a discussion of the path which each fluid A and B takes through the illustrated exchanger, a more detailed discussion of the headers **10** and **12** is believed to be in order. Headers **10** and **12** are identical and interchangeable, the headers at opposite ends merely being positioned at the time of assembly out of phase to one another by 180° in relation to the vertical axis. Accordingly, the discussion will be limited to one of the headers, namely **10**. In the practice of the invention all headers which are adapted so that both the fluids make an odd number of passes through the entire exchanger, i.e., one, three, five, etc., or any combination thereof, are interchangeable with one another as are headers **10** and **12**. If an even number of passes is desired for one or more of the fluids, the headers are not interchangeable since the fluid or fluids that make an even number of passes will enter and exit the heat exchanger through the same header.

In header **10**, a drilled dead end main conduit **58** shown in FIG. 2, is provided in communication with the inlet **34** for fluid A. The external opening of conduit **58** is closed with a plug **60**. Conduit **58** is intersected by a plurality of feeder conduits **62** which correspond to one-half the number of total horizontal rows of passageways **18** which are provided and which conduct fluid A into every other row of passageways **18** by means of a selected number of branch conduits which intersect the feeder conduits **62**. Of course, one branch conduit **64** could connect the feeder conduit **62** with all the passageways **18** in a given row. The openings through which conduits **62** and **64** were drilled are closed with plugs **66** and **68** respectively.

The conduits necessary for the three pass system, and which are in connection with every alternate row of passageways **18** is shown in FIG. 3. A selected proportion of the drilled passageways **18** in these rows dead end at a dead end branch conduit **70** which in turn is intersected by still another selected proportion of passageways **18**. The remaining proportion of drilled passageways **18** in each of the rows which carry fluid B finally dead end at another branch conduit **70*a*** which is in turn in communication with collector (feeder) conduit **72**, which connects with the outlet **42**. Branch conduits **70** and **70*a*** are closed at the drilled end with plugs **74** and **74*a***.

It will be understood by those skilled in the art, that the heat exchanger of the invention may at the time of manufacture be provided with an equal or unequal number of passes for each fluid and these passes for each fluid may range from one to a number which is dependent on the number of parallel passageways which may safely be drilled in the block and headers while maintaining sufficient strength between the passageways to resist the pressure of the fluids passing therethrough. The illustrated selection of twelve horizontal and eighteen vertical passageways is purely arbitrary as is the selection of four passageways for each pass in the three pass system. If desired, using the block illustrated as the standard, each header could be so drilled with conduits as outlined here in order to give one hundred and eight passes for each fluid. Furthermore, the passageways need not be in vertical rows or of equal diameter as illustrated, the only requirement being that the axes of all the passageways which are primarily involved in heat transfer are parallel. Likewise, the conduits may be so provided that the two fluids are diverted into an unequally divided number of rows of passageways. The unique conduit system shown in FIGS. 2 and 3 and which may be varied as outlined above permits parallel flow of the fluids virtually up to the outlets of the heat exchanger.

In order to further aid in an understanding of the invention, the course of fluid A and fluid B in counter flow relation will be followed through the illustrated heat exchanger.

Fluid A makes one pass through the system and it enters the heat exchanger through inlet **34** and flows into conduit **58** which preferably is tapered toward the bottom. The fluid A is fed into alternate rows of passageways **18** by means of the corresponding feeder conduits **62** and branch conduits **64**. Once the fluid A has passed through the entire length of the passageways it is collected and exited through outlet **44** in header **12** in exactly the inverse order in which it entered the passageways **18** in header **10**.

Fluid B makes three passes through the system and it enters the heat exchanger through inlet **36** and flows through the header **12** into passageways **18** exactly in the inverse order as will be discussed with its exit from header **10**. Fluid B first enters header **10** through a proportion of the passageways **18** and empties into branch conduit **70** from whence it flows back through the next proportion of passageways **18** into header **12** where it

is similarly turned around and returned to header **10** through the remaining proportion of passageways **18** into branch conduit **70*a***. All the fluid B exiting from such branch conduit **72** in each alternate row of passageways is collected in collector (or feeder) conduit **72** which empties into outlet **42**.

It will be appreciated that both fluids which are introduced into the heat exchanger of the invention are in contact only with impervious graphite. Thus, the heat exchangers are eminently suited for heat transfer between two corrosive liquids, between a corrosive liquid and a corrosive gas, as well as heating or cooling a corrosive solution with steam or water.

What is claimed is:

1. A heat exchanger for two fluids which comprises in combination two headers fabricated from monolithic blocks of impervious graphite, said headers being provided with a plurality of rows of horizontal drilled passageways all of whose axes are parallel to one another, said headers being so adapted that each of said fluids pass through separate horizontal rows of parallel passageways.

2. The heat exchanger of claim **1** wherein each of said fluids pass through alternate rows of said horizontal rows of parallel passageways.

3. The heat exchanger of claim **2** wherein said plurality of drilled passageways are also arranged in vertical rows and all of said passageways are uniform in size.

4. The heat exchanger of claim **3** wherein the facing surfaces of said headers are provided with grooves which extend across said faces between said horizontal rows of passageways and a gasket is provided between said headers, said gasket having a plurality of holes which correspond to said passageways in said headers.

5. A heat exchanger having an inlet and an outlet each for two fluids which comprises in combination two headers fabricated from monolithic blocks of impervious graphite, said headers being provided with a plurality of rows of horizontal drilled passageways all of whose axes are parallel to one another; alternate rows of said horizontal passageways being for one of said two fluids and being in communication with each other by means of conduits which connect all the passageways in said alternate rows to vertical conduits which are in communication with said inlet and said outlet for each one of said fluids, in order that adjacent rows of said horizontal rows will contain different fluids.

6. The heat exchanger of claim **5** wherein said plurality of drilled passageways are also arranged in vertical rows and said passageways are uniform in size.

7. The heat exchanger of claim **6** wherein the facing surfaces of said headers are provided with grooves which extend across said faces between said horizontal rows of passageways and a gasket is provided between said headers, said gasket having a plurality of holes which correspond to said passageways in said headers.

8. The heat exchanger of claim **7** wherein each of said fluids enters one of said headers and exits from the other of said headers.

9. The heat exchanger of claim **8** wherein at least one monolithic block of impervious graphite provided with a plurality of vertical and horizontal rows of drilled passageways all of whose axes are parallel and which correspond to said vertical and horizontal rows of drilled passageways in said headers, is disposed between said headers.

10. The heat exchanger of claim **9** wherein the faces of said block are provided with grooves which extend across said faces between said horizontal rows of passageways and a gasket is provided between each of said headers and said block, said gaskets having a plurality of holes which correspond to said passageways in said headers and said block.

11. The heat exchanger of claim **8** wherein said conduits which connect said alternate rows of passageways to said inlet and outlet for at least one of said fluids are so disposed in relation to said passageway that at least one of said fluids makes multiple passes through said heat exchanger.

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