Aug. 24, 1943. EMILIEN BLAIS, COMMONLY KNOWN AS EMILE BLAIR 2,327,491

SECTIONAL HEAT EXCHANGER

Filed May 6, 1941 4 Sheets-Sheet 1

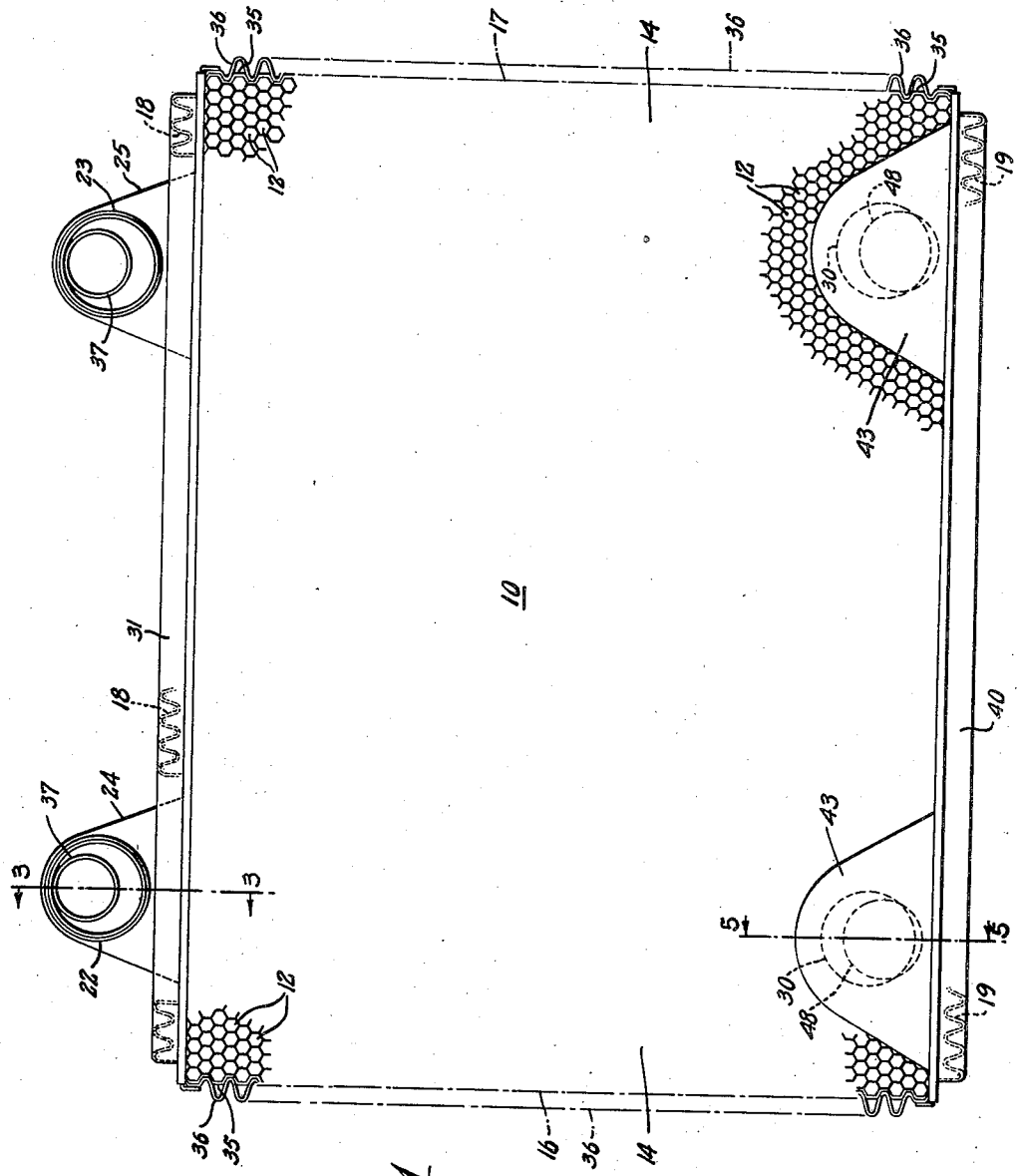



Fig. 1

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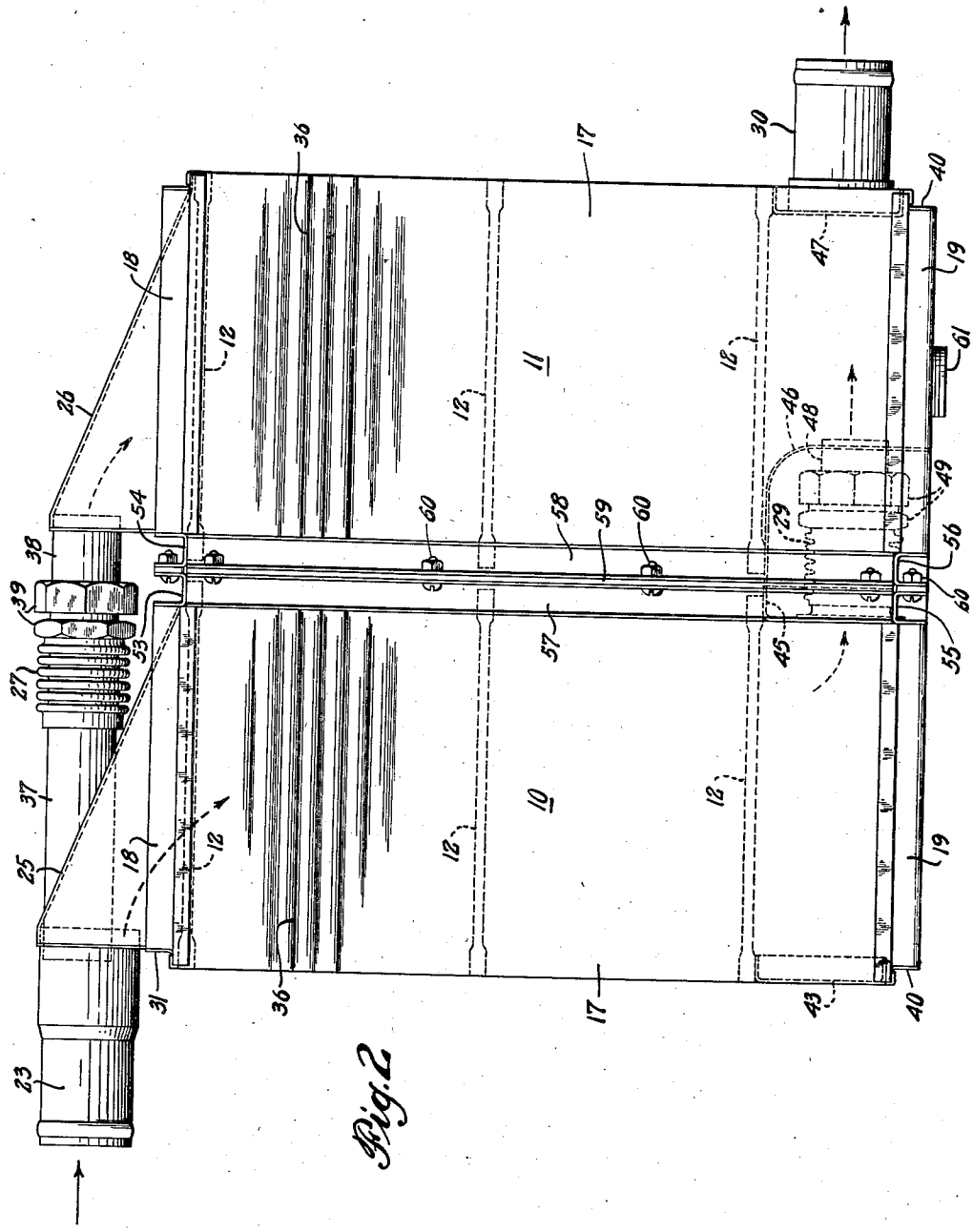



Fig. 2

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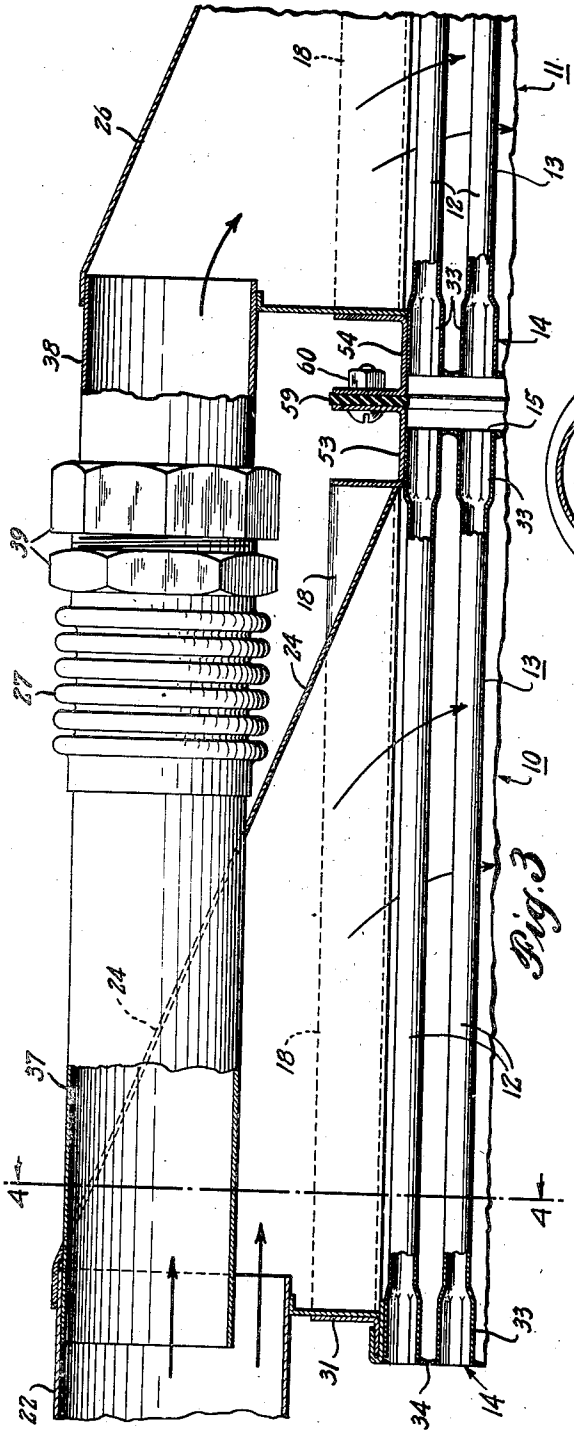


Fig. 3

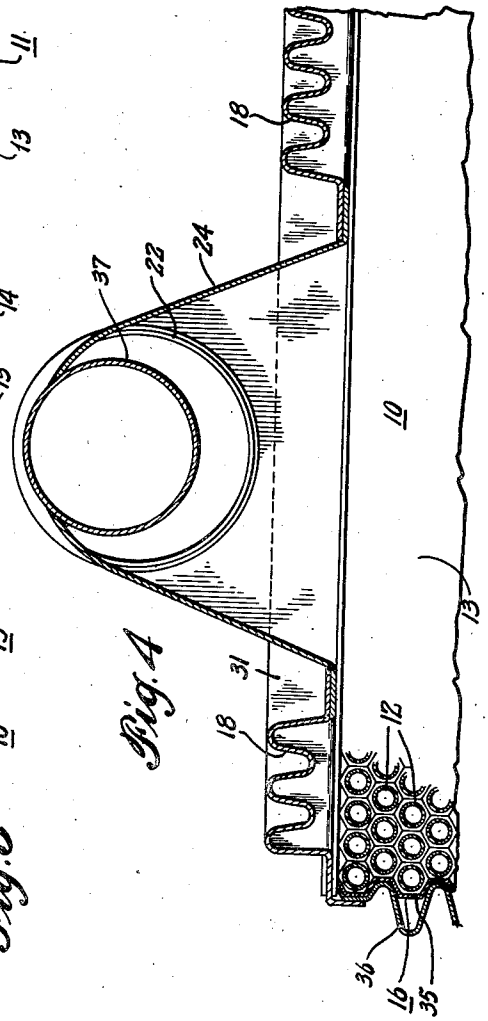


Fig. 4

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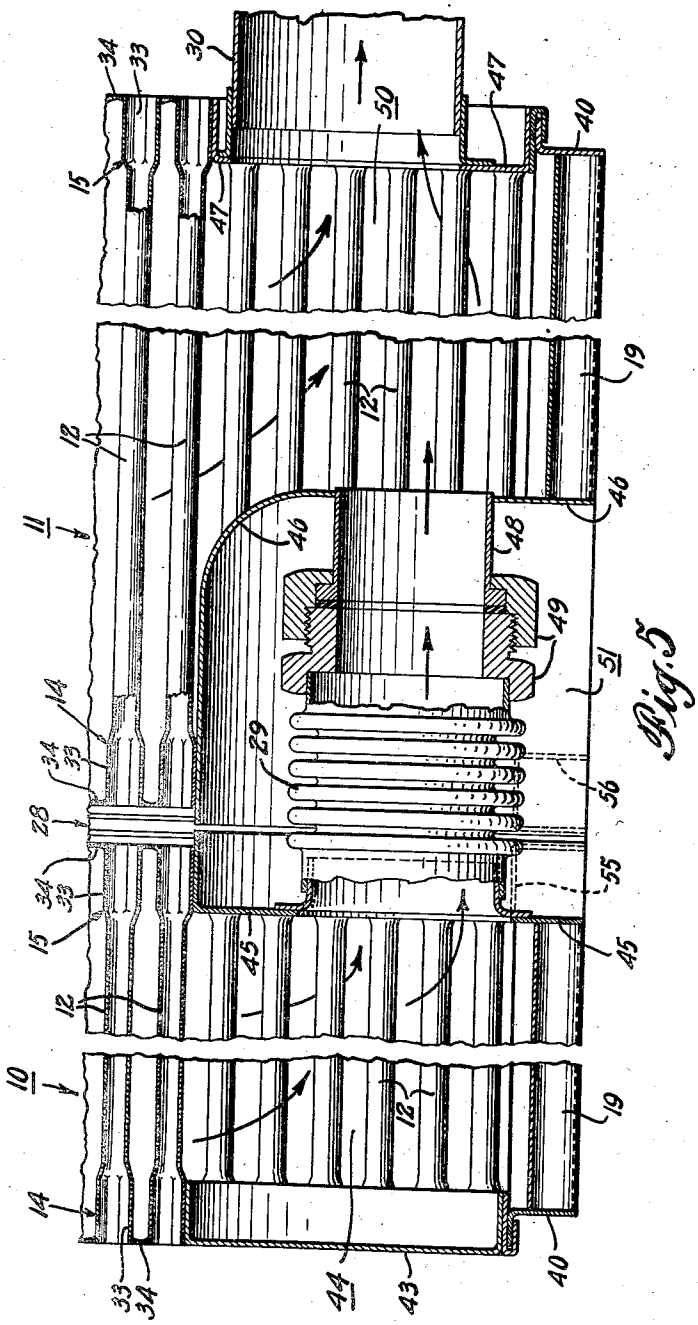



Fig. 5

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2,327,491

# UNITED STATES PATENT OFFICE

2,327,491

## SECTIONAL HEAT EXCHANGER

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Application May 6, 1941, Serial No. 392,049

10 Claims. (Cl. 257—128)

The invention relates to heat exchangers, and more particularly to heat exchangers of the cartridge type.

According to the present invention, a sectional heat exchanger is provided made up of front and rear units arranged in tandem. Each unit has a core of the cartridge type and the cores of the two units are in line so that the air path passes through the aligned tubes of the two cores. While each unit is so connected together to form a substantially rigid construction, provision is made for flexibly connecting the two units in such way as to maintain an air seal for the air path and to also provide flexible connections in the water path. Suitable ducts are connected to the top walls of the units, these ducts being connected by flexible connections. Arrangement is made for proper division of the water by making the inlet pipe for the rear section of a predetermined smaller cross-section with respect to the inlet pipe for the front section, these pipes being mounted one within the other. To provide outlet paths for the water and to save space, the tubes of the several sections are interrupted at suitable points near their bottom walls to form water passages, these passages being closed by suitable end walls connected to the surrounding headers. Suitable flexible connections are provided between the inner end walls of the two sections to connect these water passages. The outlet pipes for the entire radiator are connected to the outer end walls of the rear section.

The invention also consists in certain new and original features of construction and combinations of parts hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Fig. 1 is a front elevation of the heat exchanger according to the invention.

Fig. 2 is a side elevation of the heat exchanger.

Fig. 3 is an enlarged sectional detail taken on the line 3—3 of Fig. 1, showing the water inlet connections.

Fig. 4 is a section on the line 4—4 of Fig. 3; and

Fig. 5 is a longitudinal section taken on the line 5—5 of Fig. 1 illustrating the water outlet connections.

In the following description and in the claims, various details will be identified by specific names for convenience, but they are intended to be as generic in their application as the art will permit.

Like reference characters denote like parts in the several figures of the drawings.

In the drawings accompanying and forming part of this specification, certain specific disclosure of the invention is made for purposes of explanation, but it will be understood that the details may be modified in various respects without departure from the broad aspect of the invention.

Referring now to the drawings, and more particularly to Figs. 1 and 2, the heat exchanger according to the invention comprises in general two units or sections 10 and 11 connected in tandem, both sections being of the same general construction. Section 10 for example (see Fig. 3) comprises a stack of tubes 12 suitably nested together to form core 13, the tube ends being enlarged and soldered to form headers 14 and 15. Section 10 has side walls 16 and 17, top wall 18 and bottom wall 19 suitably soldered to the headers 14 and 15.

The air path is longitudinally through the insides of the tubes 12, the sections 10 and 11 being connected end to end with the tubes in line so as to form a substantially straight path for the air through the entire heat exchanger. The cooling liquid path is as follows: Two inlet pipes 22 and 23 are connected to ducts 24 and 25 on section 10, section 11 having similar ducts 26. Ducts 26 are connected to ducts 24 and 25 by the flexible connections indicated by 27. It will be understood that the water entering the inlet pipes 22 and 23 divides, part flowing directly through section 10 and part passing through the flexible connections 27 to section 11. Water passing downward through section 10 passes out through the bottom thereof through to flexible connections 29 where it joins with the water passing downward through section 11, section 11 being provided with two water outlets indicated by 30.

Referring now to the parts more in detail, core 13 comprises the stack of tubes 12 having enlarged hexed ends 33 suitably nested together and connected by solder 34 to form the built-up headers 14 and 15. The marginal rows of tubes may be connected by hard solder and the interior tubes may be connected with soft solder as described in my co-pending application, docket #4017.

The side walls 16 and 17 are of similar construction, each comprising an inner plate 35 and an outer plate 36 (see Fig. 4). The inner plates 35 are corrugated or bent to conform to the stacking of the tubes, and the outer plates 36 are relatively deeply corrugated to impart strength to the radiator. The top wall 18 comprises a plate having relatively deep corrugations and having openings to which are soldered the inlet ducts 24 and 25. The corrugations of plates 18 are suitably sealed as by strip 31 and by channel member 53. It will be understood that the inlet headers 26 of section 11 are similarly connected to a similar top wall.

The ducts 24 and 25 of section 10 are connected to their respective ducts 26 of section 11 by flexible conduits to permit relative movement of the two heat exchanger sections. Referring to Figs. 3 and 4, a pipe 37 passes through the wall of duct 24 and is soldered in position with its wall against the wall of the inlet pipe 22. The cross sectional areas of pipes 22 and 37 are determined by the ratio of water it is desired to distribute to the two sections 10 and 11. For substantially equal distribution the cross sectional area of pipe 37 is one-half the cross sectional area of pipe 22. Pipe 38 is connected to duct 26 and a flexible bellows 27 is connected to pipe 37 and members 27 and 38 are connected by detachable flange coupling 39. Coupling 39 is of well known construction and is similar to coupling 49 shown in cross section in Fig. 5.

Bottom wall 19 is also of corrugated construction, the corrugations being relatively deep and extending lengthwise of the tubes. The corrugations of plate 19 are suitably closed as by end strip 40 and by channel member 55, these members being suitably connected to the side plates 16 and 17 and to the headers 14 and 15.

Certain tubes at the bottom of section 10 are omitted to form two water passages 44, these passages having end plates 43 and 45 of arch or shield shape suitably connected to the surrounding headers and to the bottom wall 19. The corresponding tubes in section 11 are also omitted to form passages 50 closed by end walls 46 and 47 suitably connected to the surrounding headers and to the bottom plate. The plate 46 is dished somewhat more deeply than plates 43, 45 and 47 to provide a recess 51 of substantial size to give access to detachable coupling 49.

Water passages 44 and 50 are connected by the flexible tube 29 above-mentioned, pipe 48 being soldered within an opening in plate 46 and flexible bellows 29 being suitably connected to an opening in plate 45. Tubes 29 and 48 are connected by detachable couplings 49. Two outlet pipes 30 are connected to openings in the two end walls 47 of section 11.

For connecting the two sections 10 and 11 and to seal the air passage between these sections a flexible frame 28 is provided, made up of top and bottom channels 53, 54 and 55, 56 together with side channels 57, 58, these channels being suitably soldered to their respective sections, bottom channels 55, 56 and top channels 53, 54 serving to seal the deep corrugations of the top and bottom plates 18 and 19. A rubber gasket 59 is disposed between the channels of flexible frame 28 and is clamped in position by a series of nut and bolt assemblies 60. If desired, a drain plug may be connected in the bottom of the bottom wall of either one or both sections, a drain plug indicated by 61 being shown in the bottom wall of section 11.

It will be understood that the various water connections in the several sections are arranged in pairs, there being two inlet pipes 22 and 23, two upper flexible connections 27, two lower flexible connections 29 and two outlet pipes 30. The water will circulate as indicated by the several arrows in the several figures, the inlet pipes 22 and 23 being suitably connected to the airplane engine, or other device whose liquid it is desired to cool, and the outlet pipes 30 being also connected to the engine, as will be understood by those skilled in the art.

Thus a radiator construction is provided which has large cooling capacity, made up of units or sections which are sufficiently small to have excellent mechanical strength. The several flexible connections permit relative movement between the two units and the location of the small pipes within the larger ones provides an excellent water dividing device. The formation of water passages within the areas occupied by the cores removes the necessity for outlet connections in the bottom plates and thus saves head room, this being accomplished without substantial loss of heat exchanger efficiency. It will be understood that the tubes, walls, ducts, connecting conduits, will be made of the materials well known to those skilled in the art and they will be connected together by the usual fusible bonding material such as hard or soft solder.

Additional advantages of this invention are as follows:

Greater strength is obtained with two short tube cores than with a single long tube core. With the smaller core a smaller area is required to be supported on the side walls than with the larger core. In combat planes damage to one small core can be more readily repaired than damage to a large core. When cores made of tubes over 10" long are assembled, it is necessary to support the tubes at a point intermediate their ends by putting a bulge in the tube at approximately the center thereof. This bulge is not necessary when cores are made from tubes shorter than 10".

Better distribution of cooling liquid is obtained with radiator cores made of tubes under approximately 10" than with cores having tubes above 10". With cores having 10" or greater length there exists dead spots where the circulation is not efficient. Hence by using two cores made of tubes say 7" long as shown greater efficiency is found than when a single core made of tubes say 15" long.

The quantity of liquid passed with the arrangement of dual sections shown in this invention is increased at least 8% over the quantity passed by each section separately when not joined together as shown. Whether it is due to the Venturi action of the water leaving the left-hand section or not is not known but the increased quantity passed by the right-hand section when connected to the left-hand section as shown is at least 8%.

The flexible connection is used to make it possible to make a suitable connection due to non-alignment of openings. If the holes did not align exactly a solid nipple would not work. With an opening built up of soldered parts it is very difficult to get the exact alignment necessary for a solid nipple. Rubber hose connections are not satisfactory, hence the use of the bellows flexible connection.

While certain novel features of the invention have been disclosed and are pointed out in the annexed claims, it will be understood that vari-

ous omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What I claim is:

1. In a heat exchanger, first and second units of the cartridge type, each unit having tubes with enlarged ends stacked together, the ends being soldered to form built-up headers, each unit having top, bottom and side walls, inlet ducts connected to the top walls of said units, said units having certain tubes adjacent the bottom wall thereof omitted to form liquid passages adjacent said bottom walls, end plates connected to the adjacent headers to provide end walls for said liquid passages, the inner end plate of said second unit forming an enlarged recess, a conduit having a flexible connection located in said recess and connected to apertures in the inner end plates of said units, an outlet conduit connected to the outer end plate of said second unit.

2. In a heat exchanger, first and second units of the cartridge type, each unit having tubes with enlarged ends stacked together, the ends being soldered to form headers, each unit having top, bottom and side walls, a first inlet duct connected to the top wall of said first unit, a second inlet duct connected to the top wall of said second unit, an inlet pipe connected to said first duct, a flexible coupling connecting said ducts, said units having certain tubes thereof omitted to form liquid passages, end plates connected to the adjacent headers to provide end walls for said liquid passages, the inner end plate of one of said units forming an enlarged recess, a conduit having a flexible coupling connected to apertures in said inner end plates, an outlet conduit connected to the outer end plate of said second unit, and enclosing members secured to the top, bottom and side walls and inner headers of the respective units.

3. In a heat exchanger, first and second units of the cartridge type, each unit having tubes with enlarged ends stacked together, the ends being soldered to form headers, said units being arranged with their tubes in line, each unit having top, bottom and side walls, a pair of first inlet ducts connected to the top wall of said first unit, a pair of second inlet ducts connected to the top wall of said second unit, first inlet pipes connected to said first ducts, connecting pipes intersecting the walls of said first ducts with their ends disposed within said first inlet pipes, flexible couplings incorporated in said connecting pipes, said units having certain tubes adjacent the bottom walls thereof omitted to form liquid passages adjacent said bottom walls, shield plates connected to the adjacent headers to provide end walls for said liquid passages, the inner shield plate of said second unit forming an enlarged recess, conduits having flexible couplings connected to apertures in the inner shield plates of said units, outlet conduits connected to the outer shield plates of said second unit, U-shaped frame members secured to the top, bottom and side walls and the inner headers of the respective units, and resilient gaskets clamped between the adjacent flanges of said frame members.

4. In a sectional heat exchanger, first and second units, each unit comprising a heat exchanger core through which air is adapted to pass, said core having end faces, side walls and top and bottom walls enclosing a liquid space, said units being disposed face to face with their air paths in line, each top wall having on its outer surface a converging liquid distributing duct, each duct having an inlet pipe connected to its larger end, the pipe connected to the duct on said second unit intersecting the duct on the first unit and disposed within the inlet pipe connected to the duct on the first unit, said units having liquid outlet passages at the bottom thereof.

5. In a sectional heat exchanger, first and second units, each unit comprising a heat exchanger core through which air is adapted to pass, said core having end faces, side walls and top and bottom walls enclosing a liquid space, said units being disposed face to face with their air paths in line, each top wall having on its outer surface a converging liquid distributing duct, each duct having an inlet pipe connected to its larger end, said first unit inlet pipe constituting the main inlet to the heat exchanger, said second unit inlet pipe being connected to said first unit pipe to divide the liquid, said units having liquid passages in the bottom thereof, a conduit connecting the adjacent ends of said liquid passages and a discharge conduit connected to the liquid passage of said second unit and leading away on the opposite side of the heat exchanger from the inlet pipe to the first unit.

6. In a sectional heat exchanger, first and second sections, each section comprising a heat exchanger core through which air is adapted to pass, said core having end faces, side walls and top and bottom walls enclosing a liquid space, said sections being disposed face to face with their air paths in line, each top wall having a converging duct extending from face to face, each duct having an end face and a sloping top wall, each duct having an inlet pipe intersecting its end face, the pipe connected to the duct on said second section intersecting the sloping top wall of the duct on the first section and being disposed within the inlet pipe connected to the duct on the first section, said sections having liquid passages in the bottom thereof located within the confines of said cores, a conduit connecting the adjacent ends of the liquid passages of said units, and a discharge conduit connected to the liquid passage of said second section and leading away on the opposite side of the heat exchanger from the inlet pipe connected to the first section.

7. In a sectional heat exchanger, first and second units, each unit having headers with tubes extending therebetween, said units being disposed with their tubes in series and their inner headers adjacent, said units having certain tubes omitted to form restricted liquid passages, inner walls closing said liquid passages at their inner ends and connected to their respective adjacent inner headers, one of said inner walls being recessed to form a chamber facing the other unit, said walls having openings, and a flexible conduit connecting said openings and disposed in said chamber, said chamber permitting the use of a conduit substantially longer than the distance between said inner headers.

8. In a multiple section heat exchanger, first and second units, each unit having end faces with a first fluid path running from face to face, the units having their inner end faces disposed close together and with their fluid paths in series, a flexible wall connecting the adjacent faces of said units to connect said fluid paths, said units having second fluid paths in heat exchange relationship to said first fluid paths, one of said inner end faces having a recess therein, and a flexible connection for said second fluid connecting said second fluid paths, said recess housing

said flexible connection and permitting the use of a substantially longer flexible connection than the distance between said inner end faces.

9. In a multiple section heat exchanger, first and second units, each unit having end faces with an air path running from face to face, the units having their inner end faces disposed close together with their air paths in series, an outer flexible wall connecting the inner end faces of said units to connect said air paths, said units also having liquid paths in heat exchange relationship to said air paths, said units having inner end walls closing the inner end of said liquid paths, one of said inner end walls forming a chamber, and a flexible tube connecting the adjacent inner end walls of said units and disposed in said chamber, said chamber permitting the use of a tube substantially larger than the space between said inner end faces.

10. In a heat exchanger, first and second units, each unit having headers with tubes extending therebetween, the inner headers of said units being disposed close together, each unit having top, bottom and side walls, inlet ducts connected to the top walls of said units, said units having certain tubes adjacent the bottom wall thereof omitted to form restricted liquid passages adjacent said bottom walls, said liquid passages being surrounded on top and sides by tubes, end plates connected to the adjacent headers to provide end walls for said liquid passages, the inner end plate of one of said units forming an enlarged recess, a conduit having a flexible connection located in said recess and connected to apertures in the inner end plates of said units, an outlet duct connected to the outer end plate of one of said units, said enlarged recess permitting the use of a conduit substantially longer than the space between said inner headers.

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