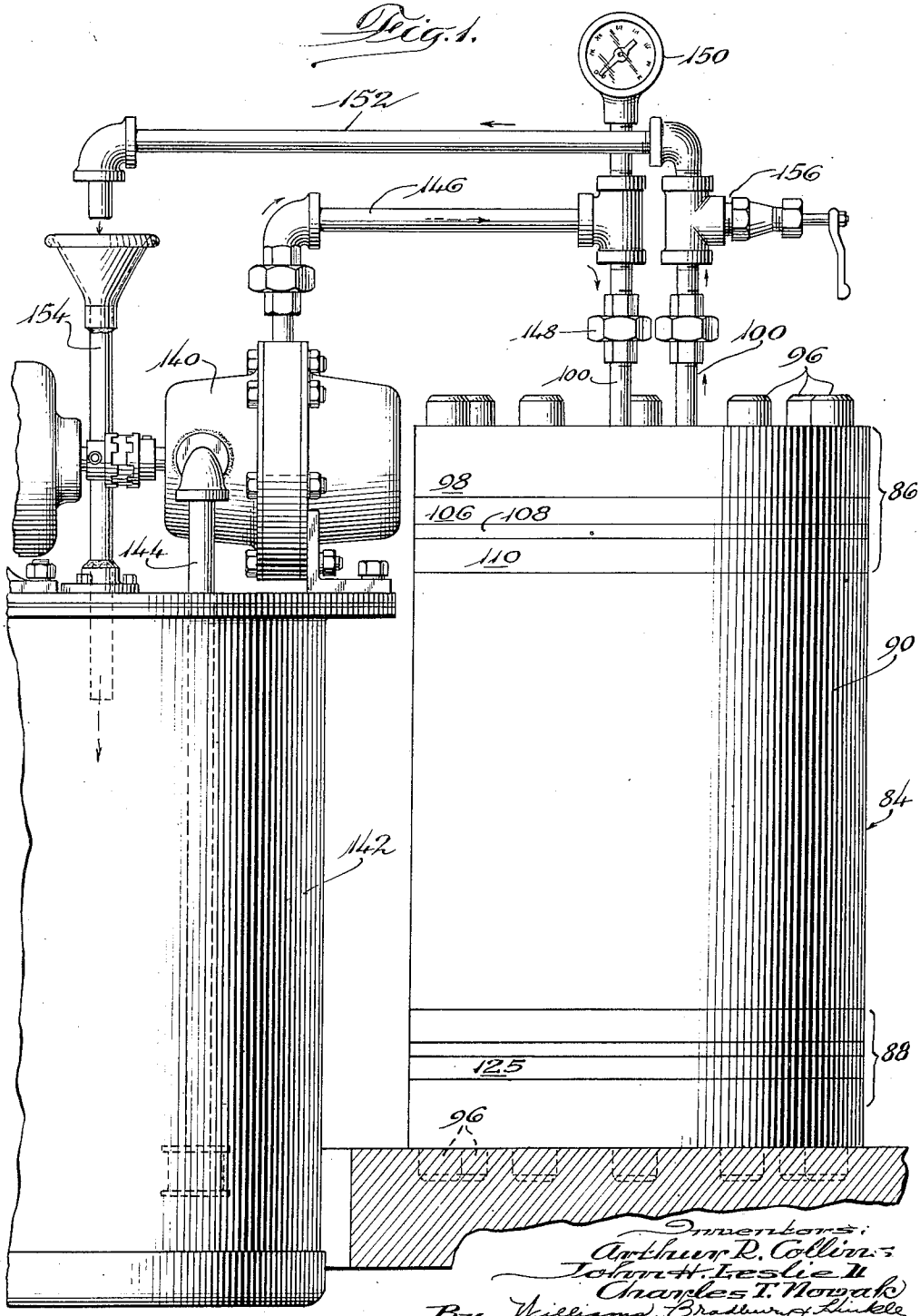
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METHOD OF AND APPARATUS FOR MAKING SPIRAL HEAT EXCHANGERS

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Fig. 1.



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Fig. 3.

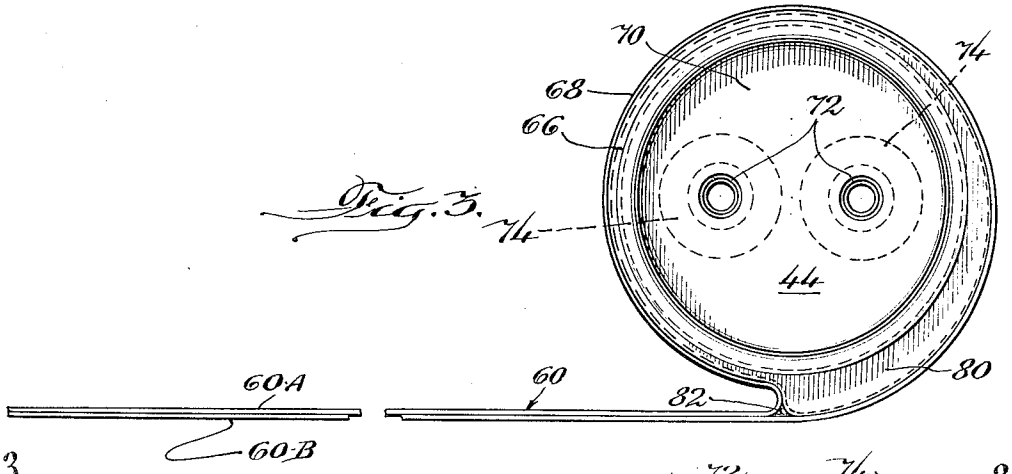
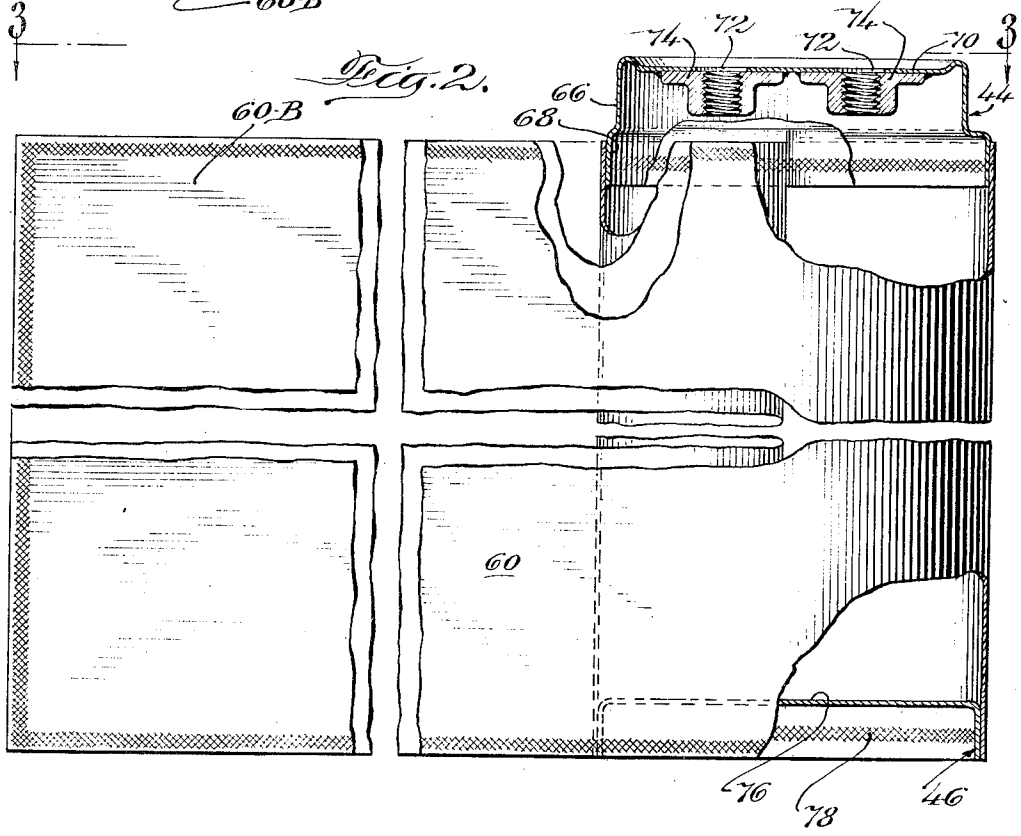


Fig. 2.

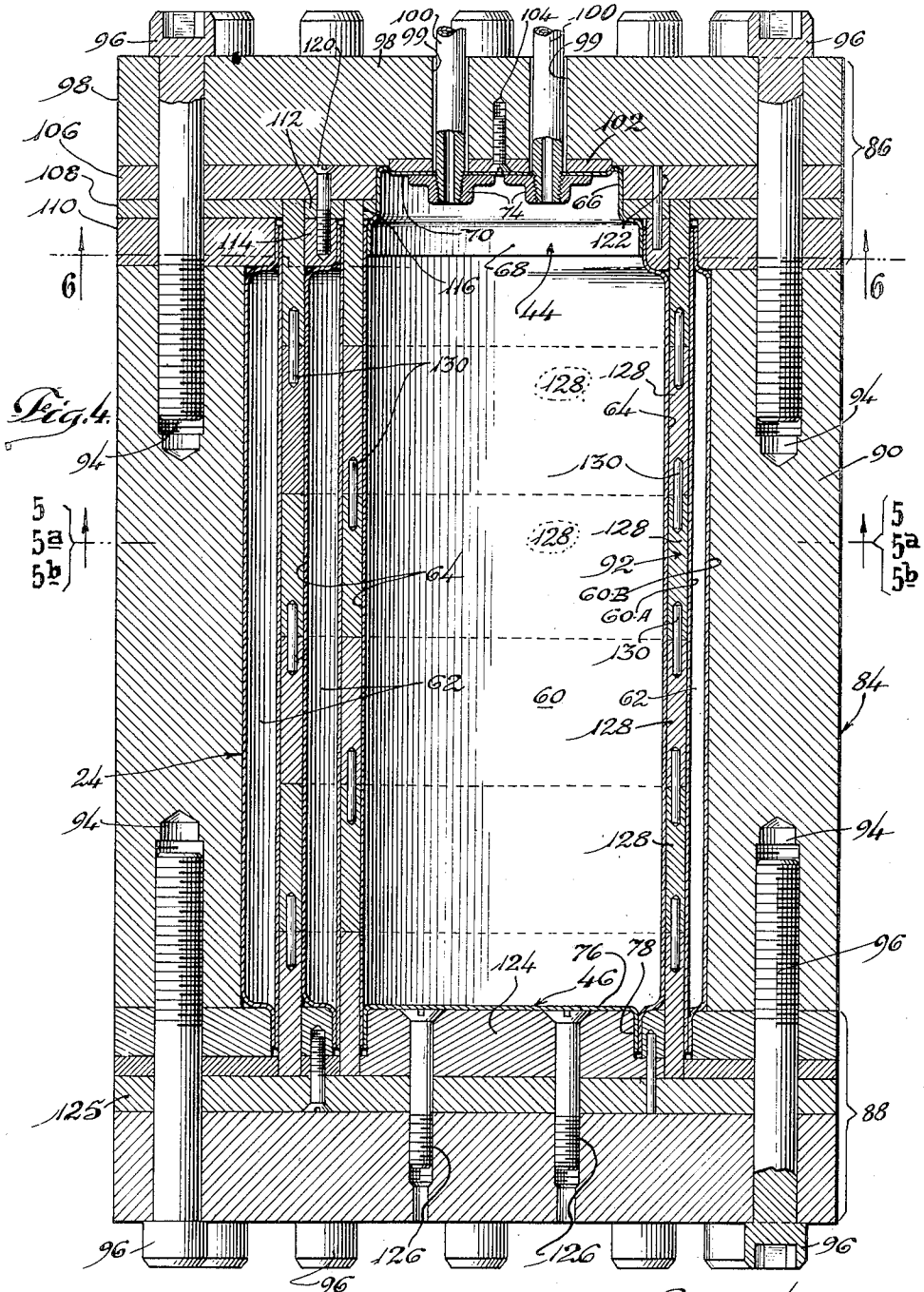


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METHOD OF AND APPARATUS FOR MAKING SPIRAL HEAT EXCHANGERS

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METHOD OF AND APPARATUS FOR MAKING SPIRAL HEAT EXCHANGERS

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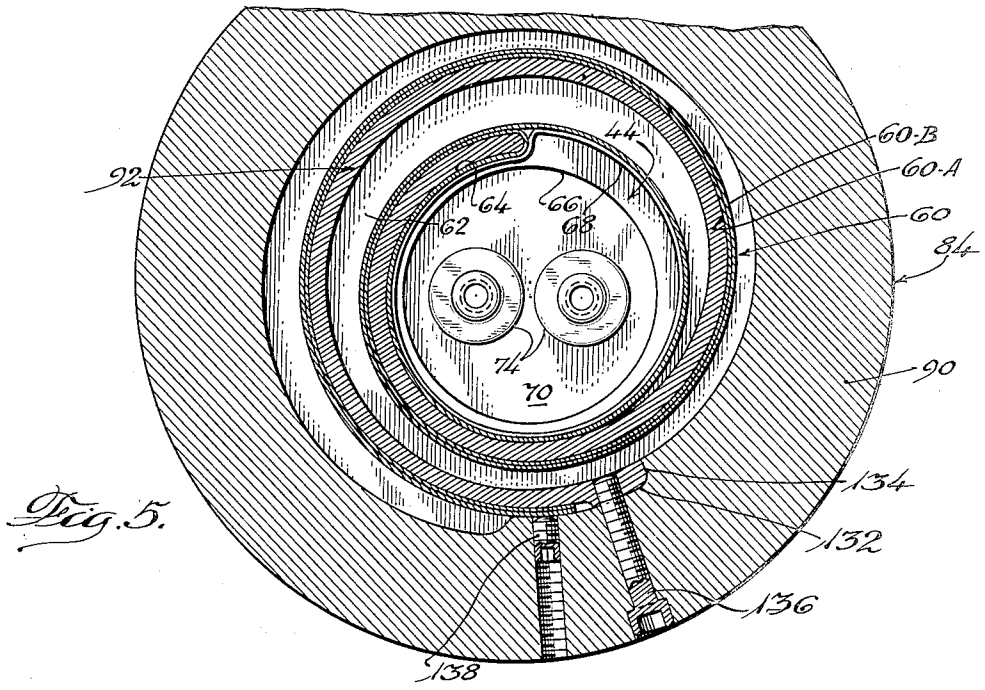


Fig. 5.

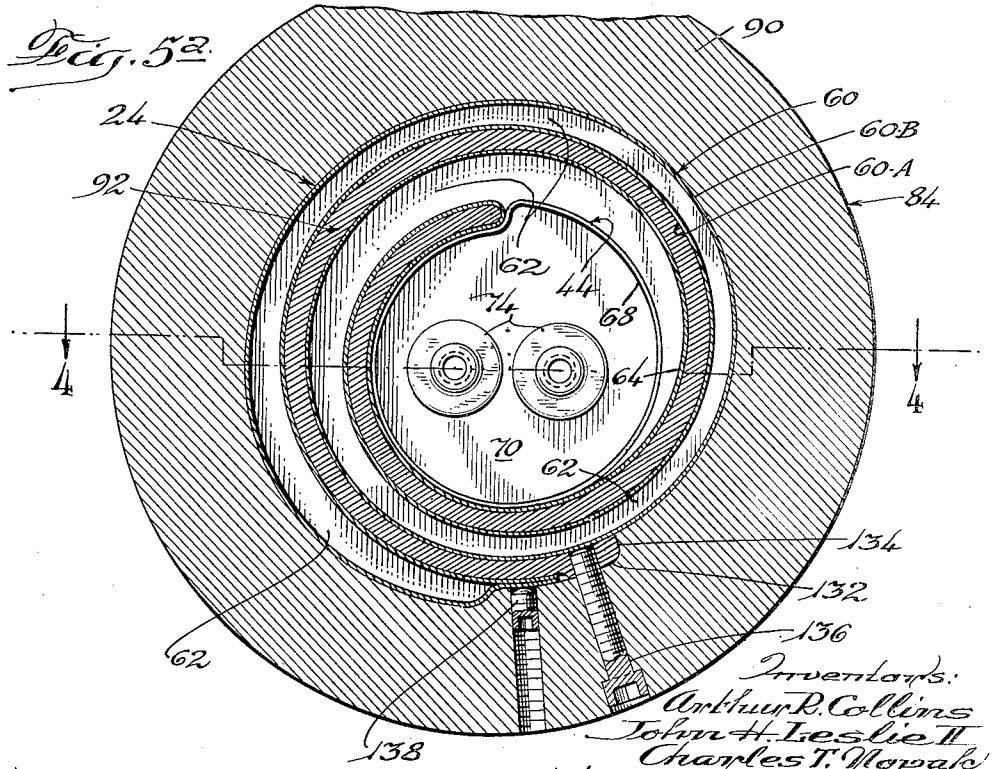


Fig. 5a.

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METHOD OF AND APPARATUS FOR MAKING SPIRAL HEAT EXCHANGERS

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Fig. 5b

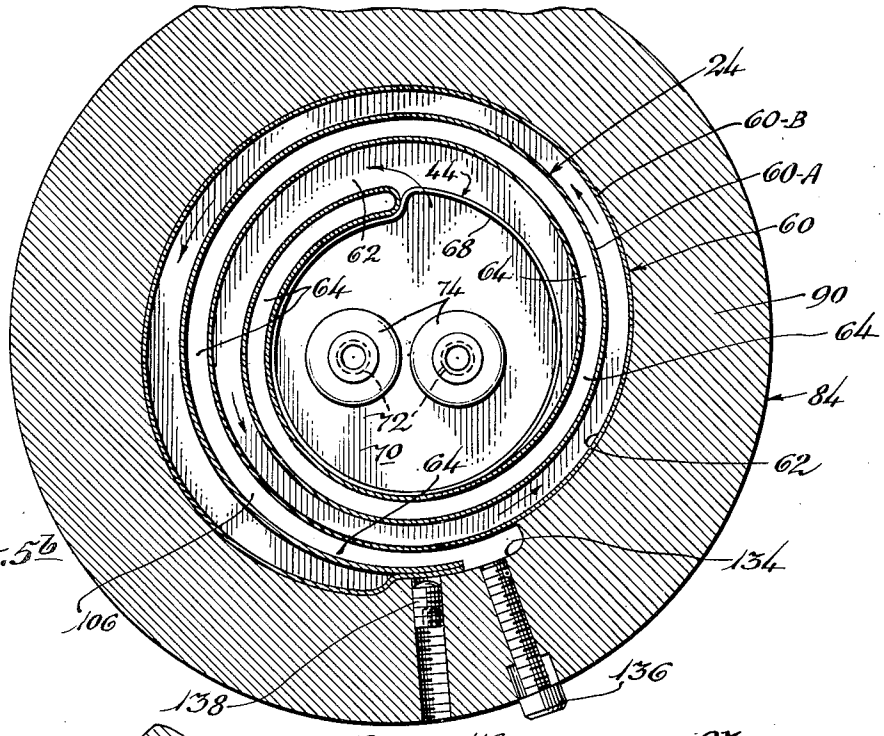
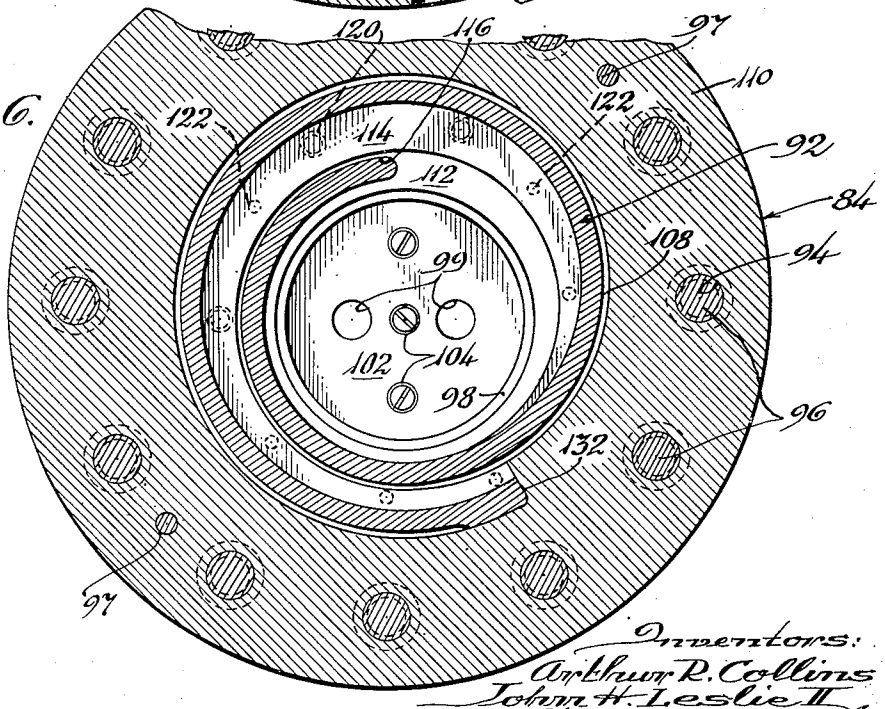


Fig. 6.



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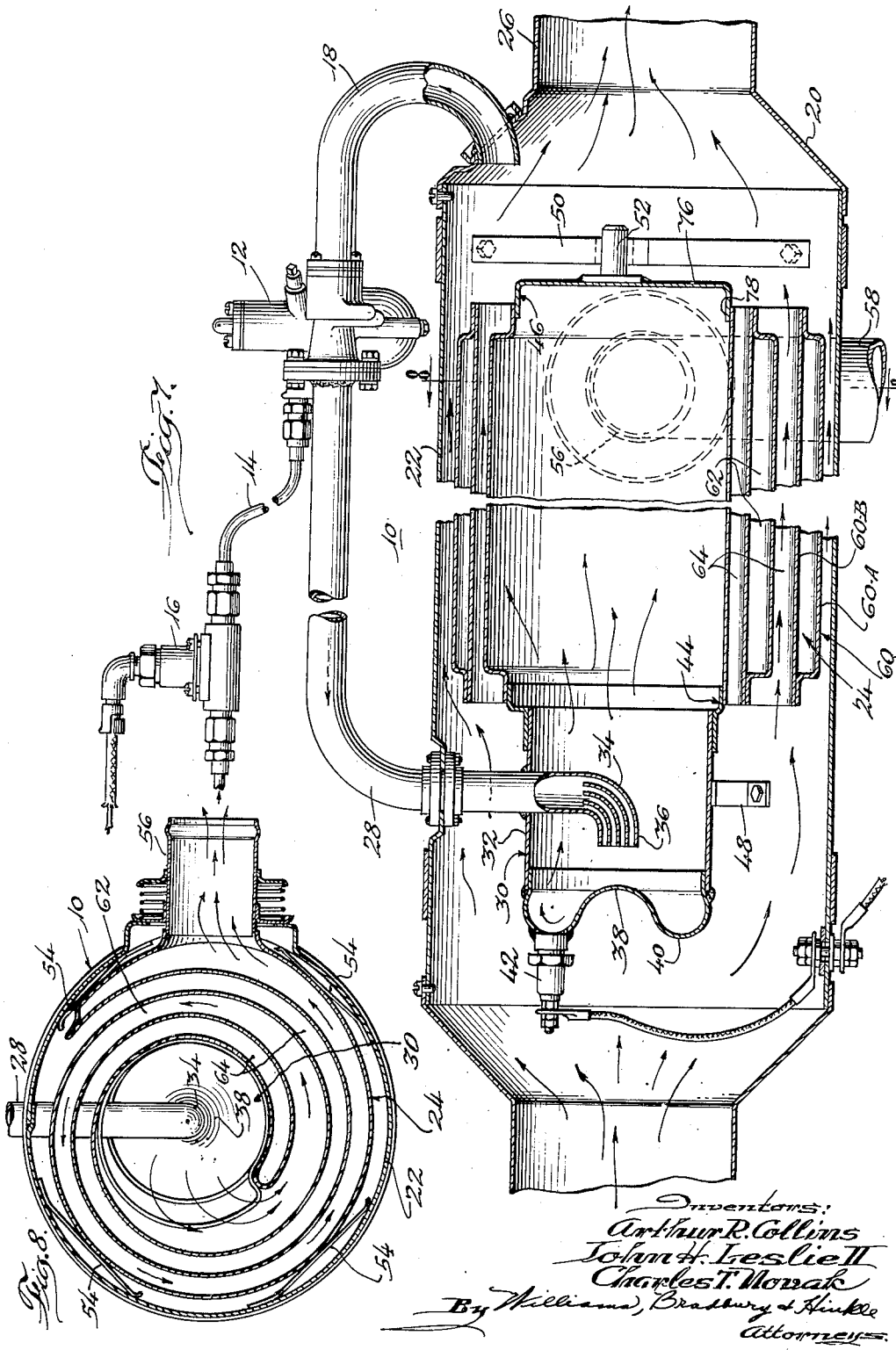
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METHOD OF AND APPARATUS FOR MAKING
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UNITED STATES PATENT OFFICE

2,507,094

METHOD OF AND APPARATUS FOR MAKING SPIRAL HEAT EXCHANGERS

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Application September 8, 1944, Serial No. 553,150

3 Claims. (Cl. 113—44)

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The present invention pertains to heat exchangers and more particularly to a method of constructing heat exchangers, apparatus for making heat exchangers, and the heat exchanger unit.

Considerable work has been done to provide improved heaters and heat exchangers for aircraft. One development is a novel type of heater including an improved form of heat exchanger having heat transfer surfaces of large area operating efficiently to transfer heat from the hot products of combustion to ventilating air. In this heat exchanger one of the fluids flows in a generally spiral path defined by spaced spirally arranged walls, while the other fluid preferably flows transversely of the first fluid through the space between the external surfaces of said walls. The generally spiral path is the one followed by the hot products of combustion which preferably enter the heat exchanger axially and centrally thereof. The other fluid, i. e., the fluid flowing transversely or axially, is the air to be heated. In order to enhance the transfer of heat, the spiral path, through which the hot products of combustion flow, is arranged so that the effective area of the path is gradually decreased, at least through a considerable portion thereof, thereby to increase the rate of heat transfer. It appears that the gradual constriction or tapering of the area and the spiral flow causes the hot products of combustion to impinge against the heat transfer surface thereby to remove a more or less stationary boundary layer which would otherwise prevent an effective transfer of heat. Heating apparatus and heat exchangers of this character are disclosed and claimed in the copending applications of William C. Parrish, Serial Nos. 490,162, filed June 9, 1943, now Patent No. 2,432,929, granted Dec. 16, 1947, and 494,155, filed July 10, 1943, now Patent No. 2,483,737, granted Oct. 29, 1949, while heat exchangers of the type including tapered conduits or passageways for the hot products of combustion are disclosed and claimed in the copending application of Lynn A. Williams, Jr., Serial No. 477,191, filed February 26, 1943, now Patent No. 2,457,513, granted Dec. 28, 1948, all of which are assigned to the assignee of the present application.

The construction of heat exchangers including spiral paths for one of the fluids has been difficult and heretofore has been done manually. As a result they can be made but slowly and expensively.

The primary object of the present invention is the provision of a new and improved method

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of making heat exchangers, a new and improved heat exchanger, and new and improved apparatus for making the heat exchanger.

Another object of the present invention is the provision of a new and improved method of making a heat exchanger which comprises the step of expanding a structure including a pair of wall defining portions into desired shape by applying fluid pressure between the wall portions.

Another and more specific object of the present invention is the provision of a new and improved method of making heat exchangers comprising the step of expanding a structure including a pair of wall defining portions by applying fluid pressure therebetween and restricting the resulting expansion or deformation of the portions so that they have a desired shape.

Another and more specific object of the present invention is the provision of a new and improved method of making a heat exchanger, which comprises the steps set forth in the preceding paragraph and wherein the structure is a double walled sealed structure within which fluid is admitted to expand the walls into the desired shape.

Another object of the present invention is the provision of a new and improved heat exchanger including a pair of coaxial end walls and a single piece of metal encircling said end walls substantially centrally thereof and extending generally spirally around at least a portion of said end walls.

Another object of the present invention is to provide a new and improved heat exchanger which may be readily fabricated by welding and the application of pressure.

A further object of the present invention is to provide a new and improved apparatus for making heat exchangers of the type specified hereinabove which includes separable parts adapted to surround the header and wrap assembly and to limit the deformation thereof under pressure so that the assembly will have the desired shape after the application of fluid pressure to expand the same.

Other objects and advantages of the present invention will become more apparent from the ensuing description of the method of making the heat exchanger, the apparatus for making the heat exchanger, and the heat exchanger itself, in the course of which reference is had to the accompanying drawings in which:

Fig. 1 is a fragmentary front elevational view, partly broken away, of apparatus for making the heat exchanger including a source of fluid pressure and of a die for limiting the expansion of

the heat exchanger unit into desired configuration;

Fig. 2 is an elevational view, partly broken away, of the heat exchanger unit in an intermediate state of manufacture, i. e., after the wrap and headers have been assembled to form the wrap and header assembly but prior to the forming thereof into spiral shape and the application of pressure therein to expand it into desired shape;

Fig. 3 is a view of the apparatus shown in Fig. 2 taken along the line 3—3 of the latter figure;

Fig. 4 is an axial cross-sectional view of the die for limiting the expansion of the assembly into desired shape and after such expansion has taken place, the view being taken along the broken line 4—4 of Fig. 5*a*;

Figs. 5, 5*a*, and 5*b* are fragmentary transverse cross-sectional views taken along the lines 5—5, 5*a*—5*a*, and 5*b*—5*b* of Fig. 4; Fig. 5 illustrates the wrap and header assembly within the die prior to the application of pressure therein; Fig. 5*a* illustrates the same after the application of pressure and the expansion of the walls into the shape defined by the die; and Fig. 5*b* illustrates the assembly within the die body but with an in portion of the die removed;

Fig. 6 is a transverse cross-sectional view of the die taken along the line 6—6 of Fig. 4, with the wrap and header assembly omitted, it may be considered also to be an elevational view of one end assembly of the die;

Fig. 7 is an axial cross-sectional view, on a reduced scale, of one form of heater with which the heat exchanger of the present invention may be utilized; and

Fig. 8 is a transverse cross-sectional view through the heater taken along the line 8—8 of Fig. 7.

Referring first to Fig. 7, it may be noted that the heater which is indicated as a whole by reference character 10 is supplied with combustible mixture by a carburetor 12 of any conventional or suitable type. The carburetor receives fuel through a fuel supply line 14 controlled by the usual solenoid valve 16. The carburetor receives combustion air from the heater through a combustion air pipe 18 which passes into the heater through a tapered outlet end 20 of the heater casing 22. This end of the combustion air pipe is so positioned that part of the heated air leaving the novel heat exchanger 24 of the present invention flows into this pipe and then to the carburetor 12. The remainder of the heated air flows to the aircraft cabin or other space or spaces to be heated through a conduit 26.

The combustible mixture of fuel and air formed by the carburetor 12 is conducted through a conduit 28 to the combustion chamber 30, the conduit passing through the heater casing 22 and wall 32 of the combustion chamber. The delivery end of the conduit 28, or induction pipe as it may be called, is curved as indicated by reference character 34 and terminates in a straight outlet portion 36 coaxial with the cylindrical wall of the combustion chamber and directed toward a dome-shaped inward projection 38 provided by the end wall 40 of the combustion chamber. The combustible mixture supplied to the combustion chamber is initially ignited by an igniter 42.

The combustion chamber illustrated has numerous advantages as set forth in the previously referred to copending application of William C. Parrish, application Serial Number 494,155. Whirling vortices of burning gases are formed within the combustion chamber from whence the hot products of combustion flow to the heat exchanger 24.

Before describing the heat exchanger in detail, it may be noted that the combustion chamber 30 is secured to one end of the heat exchanger substantially coaxially of the unit. More specifically, it is secured to a combustion end header 44, the construction of which will be described in greater detail hereinafter. The opposite end of the heat exchanger includes a header 46 closing that end. The combined combustion chamber and heat exchanger assembly is floatingly secured within the heater casing 22 in a manner enabling the assembly to move relative to the casing, thereby to avoid undue stresses and strains resulting from heating of the assembly during operation. The combustion chamber is mounted upon a bracket 48 secured to the inside of the heat exchanger casing. The opposite end is resiliently supported by a three-armed bracket 50 similarly secured to the casing and slidably receiving a pin 52 secured in suitable manner (as by welding) to the header 46. The heat exchanger 14 is resiliently held substantially centrally of the heater casing by a plurality of circumferentially spaced clips or plates 54 (see Fig. 8). These clips serve to center the heat exchanger in the casing while permitting movement thereof relative to the casing, which movement may result from expansion and contraction of the heat exchanger due to the starting and stopping of the heater. In effect, there is provided a floating mounting for the heat exchanger which provides for clockwise and counter-clockwise rotation of the outer portion of the heat exchanger relative to the casing and which also permits the heat exchanger to shift sidewise of the casing. The pin 52 permits axial expansion and contraction of the heat exchanger.

The products of combustion are exhausted through a nipple 56 which is suitably secured as by welding to the heat exchanger unit and which passes through the heater casing 22. A suitable exhaust conduit 58 may be secured to the nipple to lead the products of combustion to a suitable region.

The heat exchanger of the present invention is constructed essentially of the two previously referred to headers 44 and 46 and a wrap 60 made from a single piece of sheet metal bent back upon itself in a manner now about to be described in detail, thereby to form a double walled structure which is spiraled about the axis of the heater, the successive spirals being spaced from each other to form therebetween a pair of passageways 62 and 64, the first of which is a spiral passageway leading from the center of the heat exchanger unit to the exhaust nipple 56, and the second of which is an axial (and spiral) passageway extending from end to end of the heat exchanger unit. Passageway 62 is for a first medium, in this case the hot products of combustion, and the second passageway 64 is for a second medium, in this case the air to be heated.

The heat exchanger 24 of the present invention providing the spiral and axial passageways for the hot products of combustion and air to be heated, respectively, may be constructed both economically and simply by the novel method of the present invention. In the description of this method and of the novel heat exchanger itself and of the novel apparatus for making the heat exchanger, reference will now be had more particularly to Figs. 1 to 6, inclusive.

The heat exchanger is constructed from the previously referred to pair of headers 44 and 46 and the wrap 60, which may be made of relatively thin metal plate such as stainless steel. Referring now more particularly to Figs. 2 and 3, it may be noted that both of the headers are generally cup-shaped and are disposed with their open ends facing in the same direction for the purpose of facilitating assembly of the wrap and header assembly. The header 44 includes inner and outer axial wall portions 66 and 68, of which the former is annular and of which the latter is of somewhat different shape and larger than the former. The end wall 70 is indented somewhat and provided with a pair of apertures 72. A pair of threaded bushings 74 are secured to the inside of the end wall 70 in alignment with the apertures 72 to receive suitable fittings so that fluid may be introduced within the assembly to expand it into desired shape in manner to be described shortly. The end wall and a portion of the axial wall 66 are cut away after the heat exchanger has been formed in order that the combustion chamber 30 may be secured thereto in the manner illustrated in Fig. 7.

The other header 46 is of simpler shape having only an end wall 76 and an axial wall 78.

In order to give a suitable shape to the inner end of the passageway 62 for the hot products of combustion, the axial walls 68 and 78 of the headers are curved spirally for a portion of their peripheries as indicated by reference character 80 (see Fig. 3).

After the headers have been constructed, the wrap 60, which consists of a suitable length of stainless steel plate, is curved around and secured to the headers as best illustrated in Fig. 3. From this figure it may be noted that the wrap 60 has its central portion encircling closely the headers, and that the outer portions are substantially in abutting relation to each other as indicated by the reference characters 60A and 60B indicating the opposite end portions of the wrap.

The assembly is united and sealed in suitable manner as by seam welding wherever possible and by torch welding where seam welding cannot be used, as at the point 82 where the wrap portions 60A and 60B converge. Header 44 is first welded to the wrap through the opening provided by header 46. Then header 46 is inserted and welded to the other edge of the wrap, following which the side and end edges of the wrap portions 60A and 60B are welded together.

The wrap and header assembly, which is now in the form illustrated in Figs. 2 and 3, is then formed spirally, i. e., the portions 60A and 60B of the wrap are curved spirally around the central portion including the headers. In this stage of manufacture the assembly has the form illustrated in Fig. 5, where the assembly is illustrated in a forming die.

After the assembly has been formed spirally, it is inserted into a multi-part, separable forming die, indicated generally by the reference character 84, so that the sealed assembly may be expanded into desired shape by the application of pressure therein. It is preferred that the pressure be fluid pressure, such as oil supplied by a high pressure pump which will be described hereinafter.

The forming die 84 includes a pair of end assemblies adapted to receive the opposite ends of the spiral header and wrap assembly, an external die body adapted completely to surround the outside of the assembly, and a spiral passage spacer located centrally of the die and defining passages

adapted to receive the assembly. The interior of the die body and the spacer are shaped to conform to the shape desired to be given to the heat exchanger. Preferably, the spacer is shaped to conform to the axial air passages so that the space between portions of the spacer and between the spacer and the inner surface of the die body are of a shape corresponding to the shape desired to be given to the spiral passageway for the hot products of combustion.

Referring now more particularly to Figs. 4 to 6, inclusive, and particularly to Fig. 4, it may be seen that the die 84 includes the spaced apart end assemblies 86 and 88, a central generally annular die body 90, and the central inner air passage spacer 92. The annular die body 90 may be made of a single piece of metal and it is provided at its ends with a plurality of circumferentially spaced apart threaded openings 94 adapted to receive bolts 96 for securing the main components of the forming die. Accurate positioning is provided by the diametrically opposite pins 97 (Fig. 6).

The end assembly 86 includes a relatively thick end plate 98, which is provided with a pair of apertures 99 for the purpose of receiving coupling conduits 100 adapted to be threaded into the bushings 74. The end assembly also includes a number of parts which, when assembled together, are adapted to receive the combustion end header and the combustion end of the header and wrap assembly. These parts include a central circular plate 102 seated within a central recess in end plate 98 and secured thereto by the countersunk screws 104. An annular plate 106 is located next to the end plate and it has a central circular aperture for receiving the axial annular side wall 66 of header 44. The end assembly includes also a pair of outer generally annular plates 108 and 110, which are provided with generally central openings to receive, respectively, portions of the outer surfaces of the air passage spacer 92 and the welded end portion of the wrap. The shape of plate 110 is best illustrated in Fig. 6. The remaining portions of the spacer 92 and of the welded portion of the wrap are secured by retainer rings 112 and 114, respectively. Retainer ring 114 abuts against the outer portion of retainer ring 112 and has a configuration corresponding to the cross section desired to be given to the passageway 62 for the hot products of combustion. The retainer ring 112 is provided with a spiral slot 116 to receive the end of the spacer 92. The retainer rings 112 and 114 are secured to plate 106 by screws 120, and better positioning is provided by a plurality of pins 122 extending through the plate 106, the retainer ring 112, and into retainer ring 114.

The end assembly 88 is constructed like the assembly 86, except that it faces in the opposite direction, and the central circular plate 124 is shaped to receive the header 46, which, it may be remembered, has a somewhat simpler configuration than the header 44. Accordingly, the plate 124 may be utilized to perform a function performed by a portion of the retainer ring 112. In addition, a plate 125 corresponding to plate 106 is not apertured, and screws 126 are utilized to secure the latter plate and plate 124 to the end plate corresponding to plate 98. In view of the similarities in construction, it is believed that a further description of end assembly 88 is not required.

The spacer 92 is generally spiral in shape, and

as heretofore indicated, dimensioned to correspond to the dimensions desired to be given to the axial air passageway 64. It is slightly longer than the heat exchanger, and because of its length is preferably formed of a number of relatively short sections 128 (see Fig. 4) which are positioned fixedly relative to each other by a plurality of pins 130 spaced circumferentially about the spacer and each extending into adjacent spacer sections. The outer end 132 of the spacer (the outermost—spirally—part of the spacer) is of somewhat greater thickness than the remainder and it fits into a longitudinal recess 134 within the interior of the die.

The spacer is secured to the remainder of the die by a plurality of longitudinally spaced apart set screws 136 accessible from the exterior of the die and threaded to both the die body 90 and the spacer 92, as best illustrated in Figs. 5 and 5a. To release the spacer from the die body, the screws are adapted to be moved outwardly as indicated in Fig. 5b.

The outermost end (spirally) of the header and wrap assembly is adapted to be secured to the die body and spacer by a plurality of longitudinally spaced apart set screws 138, as indicated in Figs. 5 and 5a. The release of the parts is effected by screwing out the set screws, as indicated in Fig. 5b.

Returning now to the method of making the heat exchanger, it will be remembered that the method was described up to the point where the header and wrap assembly was formed spirally. Thereafter, the spiral assembly is located within the forming die, which is separable, and secured thereto as shown in Fig. 5. This view illustrates the position and condition of the heat exchanger itself and in relation to the die prior to expansion by fluid pressure.

The heat exchanger is expanded into a shape defined by the forming die by the application of fluid pressure within the interior by apparatus illustrated in Fig. 1 and which will be described shortly. Fluid under pressure is admitted to the interior of the heat exchanger through one of the conduits 100. As the pressure increases, the heat exchanger is gradually expanded so that the portions are forced against the spacer and die body and end assemblies, as the case may be. At this time the heat exchanger is in the position and condition illustrated in Figs. 4 and 5a.

After the heat exchanger has been formed, the parts of the die are released therefrom, as by unscrewing the bolts 136 and set screws 138, after which the die assembly may be disassembled to permit removal of the heat exchanger.

The die itself may take various forms, although the one illustrated is preferred. Likewise, different means may be employed for expanding the heat exchanger. An illustrative example of such means is shown in Fig. 1, to which reference is now had. Fluid, preferably oil, is pumped under high pressure to the interior of the heat exchanger, which is located within the forming die 84. The high pressure oil is supplied by a motor driven pump 140 which may be of any suitable and convenient construction. The oil is supplied to the suction side of the pump from an oil reservoir 142 through an inlet conduit 144. Oil flows from the pump to the heat exchanger through a discharge conduit 146 and a coupling 148 provided so that the die assembly may be readily connected to the fluid pressure supply means. A pressure gauge 150 is included in the outlet conduit 146 so that the applied pressure may be readily ascertained.

When oil is initially supplied to the forming die, it is desirable to vent the air contained therein, and this is done through one of the conduits 100 and a venting conduit 152 opening into a funnel topped conduit 154, preferably mounted on top of and leading to the fluid reservoir 142. In order to close this conduit and to enable the pressure to be built up within the forming die, the venting conduit is provided with a hand operated shut-off valve 156.

When the heat exchanger unit has been formed by fluid pressure, the die may be disconnected from the fluid pressure source and the oil removed from the interior of the heat exchanger in any suitable manner. For instance, it may be removed after the heat exchanger has been taken out from the forming die or it may be removed by dumping the assembly.

The only operation necessary to make the heat exchanger available for use in the heater illustrated in Figs. 7 and 8, is the cutting off of the end wall of the combustion end header 44. After this has been done, the heat exchanger unit is ready for assembly with the combustion chamber and for installation in the heater casing, as described heretofore.

While we have shown and described a particular embodiment of our invention, it will be apparent that numerous variations and modifications thereof may be made without departing from the underlying principles of the invention. We, therefore, desire, by the following claims, to include within the scope of our invention all such variations and modifications by which substantially the results of our invention may be obtained through the use of substantially the same or equivalent means.

We claim:

1. A method of making a heat exchanger comprising forming a pair of generally circular headers, wrapping around the headers a piece of metal plate having a length substantially greater than the perimeters of the headers, said headers being spaced apart, securing to said headers the portions of the wrap encircling the headers and securing the remaining portions of the wrap to each other at their marginal areas, thereby to form a sealed structure, curving the bilaminar portion of the wrap extending beyond the headers into a generally open spiral form about the headers, placing the header and wrap assembly into a die which includes a spiral structure dimensioned to fit between adjacent turns of the spirally curved wrap with clearance, and applying fluid pressure within said structure to expand the bilaminar portion of the assembly against the spiral die structure to the extent of said clearance to form a spiral passageway leading from the space between the headers.

2. A method of making a heat exchanger comprising forming a pair of generally circular headers, wrapping around the headers a piece of metal plate having a length substantially greater than the perimeters of the headers, said headers being spaced apart, securing to said headers the portions of the wrap encircling the headers and securing the remaining portions of the wrap to each other at their marginal areas, thereby to form a sealed structure, curving the bilaminar portion of the wrap extending beyond the headers into a generally open spiral form about the headers, placing the header and wrap assembly into a die which includes a spiral struc-

ture dimensioned to fit between adjacent turns of the spirally curved wrap with clearance, and applying fluid pressure within said structure to expand the bilaminar portion of the assembly against the spiral die structure to the extent of said clearance, removing the heat exchanger from the die structure, and cutting away a portion of one header to provide means for securing a combustion chamber to the heat exchanger.

3. A die for expanding into desired shape a spiral heat exchanger having a spiral portion with welded edge portions, including in combination, end portions adapted to abut against and hold the welded edge portions of the unit, a separable interposed outer portion adapted to be secured between the end portions, and an interposed generally spiral inner portion adapted to be secured between the end portions and to said outer portion, the spiral die portion having a space to receive the spiral portion of the unit and to limit the expansion thereof into desired shape, and said interposed portions also having means for clamping the outer end of the spiral portion of said heat exchanger within said die, together with means for introducing fluid under pressure into the heat exchanger for expanding it within the die.

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