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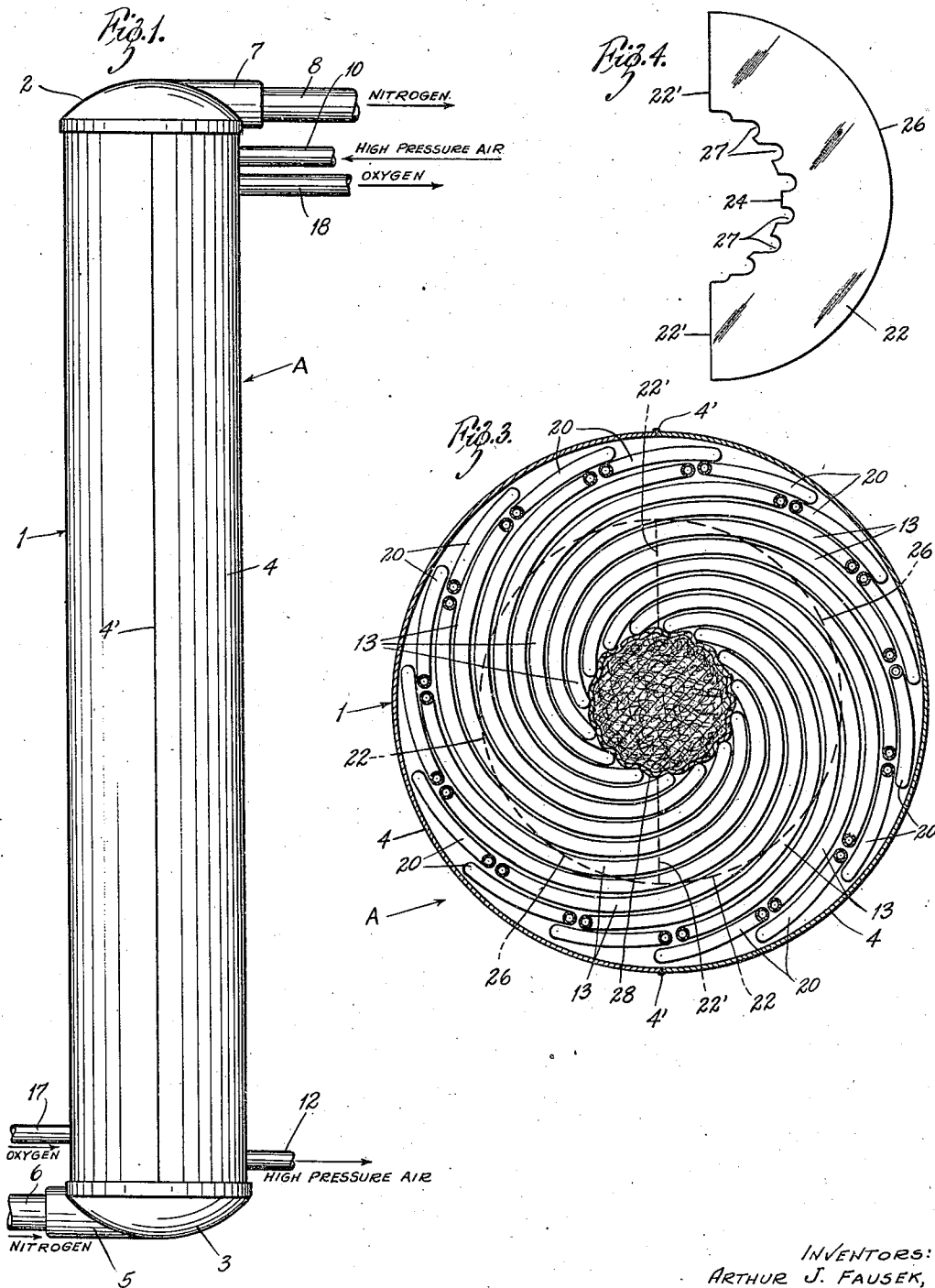
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2,402,881

HEAT EXCHANGER

Filed Jan. 2, 1943

2 Sheets-Sheet 1



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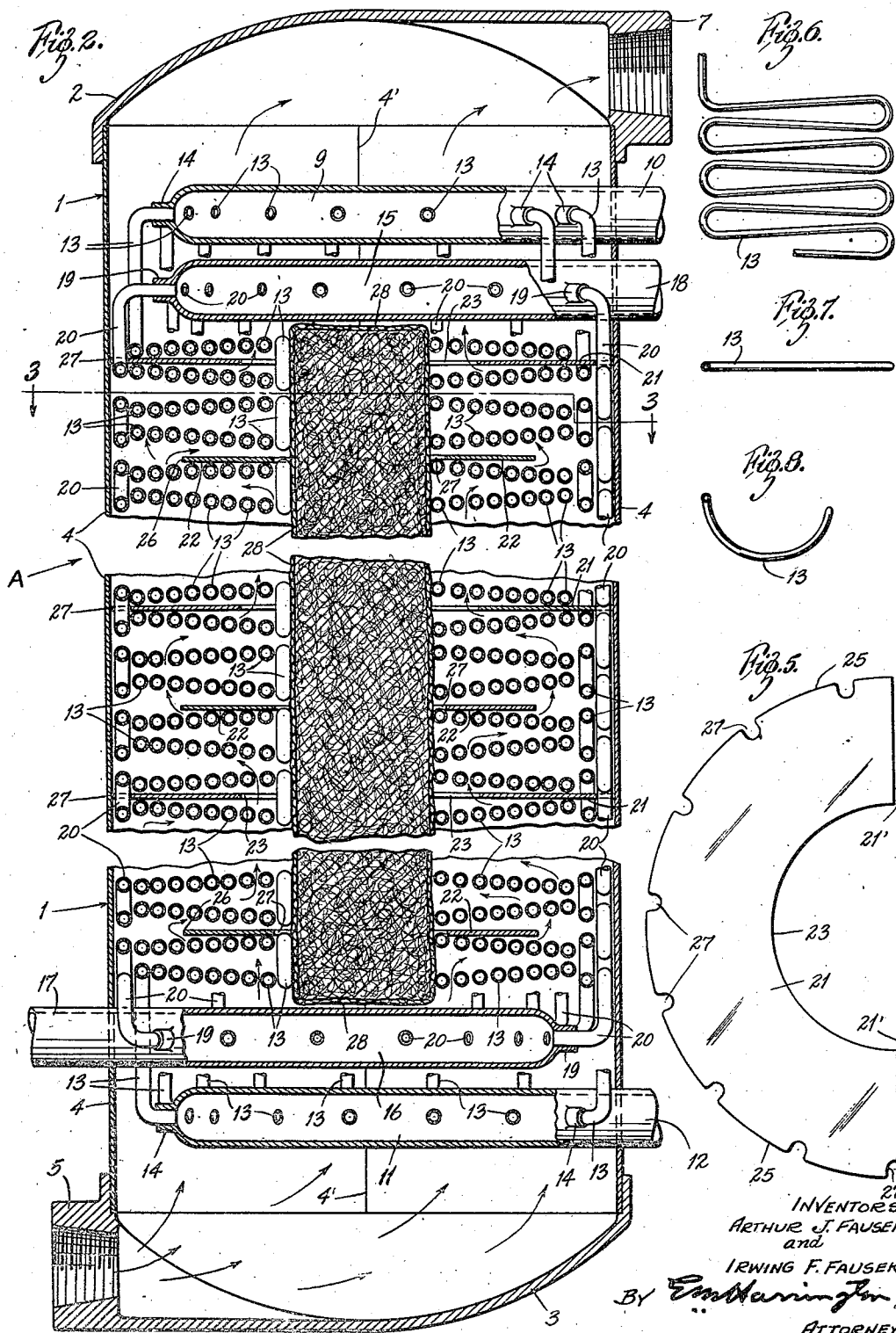
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HEAT EXCHANGER

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This invention relates generally to heat exchangers and more specifically to heat exchangers of the type comprising a multiplicity of tubes arranged within a housing, through which tubes and housing fluid, gas, or other medium, whose temperature is to be changed, passes, the predominant object of the invention being to provide a heat exchanger of the type mentioned, which includes tubes of such form and arrangement that a maximum of heat exchange is obtained in a housing of relatively small diameter and reduced height and which tubes may be conveniently removed for repair or replacement.

Prior to this invention heat exchangers of the general type to which the structure of the present invention relates were deficient in two major respects, these points of deficiency being, first, that when the tubes were long and straight the heat exchanger was necessarily of very great height or length, in order to obtain the desired heat exchange, and, secondly, that when other than straight tubes were employed, or when an excessive number of shorter straight tubes were used, the height or length of the heat exchanger was reduced but the task of removing tubes for repair or replacement was rendered most difficult.

The prime purpose of this invention, therefore, is to provide a heat exchanger which is of such unique construction and arrangement that the structure is of minimum height and the tubes thereof may be conveniently removed for repair or replacement, such result being a consequence of the form of the tubes and their arrangement within the housing of the heat exchanger.

Fig. 1 is a side elevation of the improved heat exchanger, conductors leading to and from the heat exchanger being broken away.

Fig. 2 is an enlarged vertical section taken through the heat exchanger shown in Fig. 1, portions of the structure being broken away in order to permit of the view being drawn to a larger scale.

Fig. 3 is a horizontal section taken approximately on line 3-3 of Fig. 2.

Fig. 4 is a plan view of a section of one of the baffles forming a part of the heat exchanger illustrated in Figs. 1 and 2.

Fig. 5 is a plan view of a section of another of the baffles of the improved heat exchanger.

Fig. 6 is an elevation on a reduced scale of one of the tubes of the heat exchanger illustrating the form thereof before final shaping of said tube.

Fig. 7 is a sectional-plan view of the tube illustrated in Fig. 6.

Fig. 8 is a sectional-plan view of one of the

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tubes after its final shape has been imparted thereto.

The improved heat exchanger disclosed herein may be employed for the purpose of changing temperatures of various mediums which are capable of flowing, and in order to disclose one embodiment of the invention for purposes of illustration, merely, we illustrate in the drawings a heat exchanger of the improved construction and arrangement which is adapted particularly for use in increasing the temperatures of nitrogen and oxygen. The improved heat exchanger is designated generally in the drawings by the reference character A and it comprises an outer housing 1 which includes a top member 2, a bottom member 3, and a shell 4 of tubular or other suitable shape. The top member 2 and the bottom member 3 are secured to top and bottom portions of the shell 4 in any suitable manner to provide fluid and gas-tight joints at the points of connection between said top and bottom members and the shell, the bottom member 3 being provided with a boss 5 provided with a screw-threaded opening which communicates with the interior of the housing and receives a nitrogen inlet conductor 6, and the top member 2 being provided with a boss 7 provided with a screw-threaded opening that communicates with the interior of the housing and receives a nitrogen outlet conductor 8.

Arranged within the upper portion of the housing 1 is a manifold 9 for high pressure air, said manifold having a portion extended through an opening formed through the wall of the shell 4 to provide an exterior inlet conductor 10 which conducts high pressure air to the manifold 9. Also, arranged in the lower portion of the housing 1 is a similar manifold 11 for high pressure air which likewise includes a portion that extends through an opening formed through the wall of the shell 4, this portion providing an exterior outlet conductor 12 which conducts high pressure air from the manifold 11. Preferably, though not necessarily, the portions of the manifolds 9 and 11 which are located within the housing 1 are of circular formation with the inlet and outlet conductors 10 and 12 leading to the circular portions of the respective manifolds. Also, the joints between the surfaces of the inlet and outlet conductors 10 and 12 and the walls of the openings through which said conductors pass, are suitably sealed to render said joints fluid and gas-tight.

Extended between the manifold 9 and the manifold 11 is a plurality of high pressure air pipes 13

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each of which is connected into the manifold 9 at its upper end and is similarly connected into the manifold 11 at its lower end. The manifolds 9 and 11 are provided with outwardly extended, hollow bosses 14 which communicate with the interiors of the manifolds and receive opposite end portions of the pipes 13, said end portions of the pipes being soldered or otherwise secured to the bosses to provide fluid and gas-tight contact therebetween. Each of the pipes 13 has a tortuous formation, being made up of a multiplicity of return bends and connecting portions between said return bends, as shown in Fig. 6, which extend continuously throughout substantially the entire length of the pipe. Also, the undulant portion of each pipe, made up of the return bends and the connecting portions therebetween, is curved transversely, as shown in Fig. 3, so as to provide for the close nesting of a multiplicity of said pipes in the relatively small space provided within the housing 1.

The importance of the transverse curvature of the pipes 13 which permits of said pipes being nested within the housing 1, as shown in Fig. 3, will be realized if it be considered how very much larger in diameter the housing would have to be if an equal number of uncurved pipes were arranged radially within a housing. Also, in such an imagined arrangement much space within the housing would be unoccupied by pipes, and much of the medium passed through the housing for the purpose of changing the temperature thereof would not come into close contact with the pipes, with the result that the heat exchanging operation would not be efficiently performed. In the structure of the present invention, however, the pipes 13, because of the curvature thereof and the consequent closely nested condition of said pipes within the housing, substantially fill the entire space within the housing 1 so that medium passing through the housing exteriorly of the pipes 13 for the purpose of changing the temperature thereof, must necessarily move in close contact with said pipes 13, with the consequence that the heat exchanging operation is very effectively performed.

Another important feature of the present invention is that in spite of the closely nested condition of the pipes 13 any one of said pipes may be conveniently removed for repair or replacement. Such removal of a pipe may be accomplished by disconnecting the opposite end portions of the pipe from the manifolds 9 and 11 and then rotating the pipe to be removed laterally to move same in a curved path, out of its position in the nest of pipes. In this connection it is pointed out that the shell 4 is made up of a pair of semicircular sections which are soldered or otherwise secured together at opposed butt joints 4' which extend longitudinally of the shell from end to end, as shown in Fig. 3. Because of this arrangement the paired sections of the shell may be disconnected at the joints 4' and separated after the top and bottom members 2 and 3 have been removed, to give free access to the nested pipes 13.

Arranged in the upper portion of the housing 1, immediately below the manifold 9, is an oxygen manifold 15, and arranged in the lower portion of the housing 1, immediately above the manifold 11 is a similar oxygen manifold 16. The manifolds 15 and 16 correspond in construction to the manifolds 9 and 11 in that the portions thereof which are located within the housing are of circular formation. Also, the mani-

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fold 16 includes a portion which extends through an opening formed through the wall of the shell 4 to provide an oxygen inlet conductor 17, while the manifold 15 includes a similar part extended through an opening formed through the wall of the shell 4 which provides an oxygen outlet conductor 18, the contacting points of the surfaces of the inlet and outlet oxygen conductors and the walls of the openings being suitably sealed. The oxygen manifolds 15 and 16 have formed thereon outstanding, hollow bosses 19 which communicate with the interiors of said manifolds.

Arranged within the housing 1 of the heat exchanger A is a plurality of oxygen pipes 20 which extend between, and are connected, at their opposite ends, into the manifolds 15 and 16, each oxygen pipe 20 having its opposite end portions received by corresponding bosses 19 of the manifolds 15 and 16 and said end portions of the oxygen pipe being secured by solder, or otherwise, to said bosses so as to provide fluid and gas-tight contact therebetween. As in the case of the high pressure air pipes 13 each of the oxygen pipes 20 has a tortuous formation, being made up of a plurality of return bends and connecting portions between said return bends which extend continuously throughout substantially the entire length of the oxygen pipe. Also, as in the case of the high pressure air pipes 13, the undulant portion of each oxygen pipe 20, made up of the return bends and the connecting portions therebetween, is curved transversely, as shown in Fig. 3, the oxygen pipes differing from the high pressure air pipes only in that the undulant portions of the oxygen pipes are of less width than the corresponding portions of the high pressure air pipes, and because the high pressure air pipes are of heavier wall thickness to hold the high pressure air. As shown in Fig. 3, the oxygen pipes 20 are nested with respect to the high pressure air pipes 13 within the housing 1, each oxygen pipe being arranged in curved alignment relative to one of the high pressure air pipes.

Arranged within the housing 1 and suitably supported therein, is a plurality of baffles 21 and 22. The baffles 21 and 22 are disposed within the housing 1 in staggered relation so as to cause nitrogen passing upwardly through the housing to follow a tortuous course, thereby preventing short-circuiting of said nitrogen through the housing, and causing it to move in contact with a maximum number of portions of the high pressure air pipes 13. Each of the baffles 21 and 22 is made up of a pair of semicircular sections, as shown in Figs. 4 and 5, these sections being arranged in abutting relation at their spaced straight, inner edges 21' and 22' to provide the complete baffle. Also, each baffle section includes an inner edge 23 or 24 between the spaced straight, inner edges 21' or 22', which is curved to correspond with the curvature of the outer edge 25 or 26 of the baffle section. The arrangement of the baffles within the housing is such that the inner curved edges 23 of the baffles 21 are spaced a substantial distance in an outward direction from the axis of the housing 1, while the outer curved edges of the baffles 22 are spaced inwardly a considerable distance from the inner face of the wall of the shell 4 of the housing 1. Because of this arrangement the nitrogen passing upwardly through the housing will follow a tortuous path, as mentioned above, the body of nitrogen flowing around the outer edges 26 of the baffles 22 and around the inner edges 25 of the baffles 21 as indicated by the arrows in Fig. 2.

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Additionally the inner, curved edges 24 of the baffles 22 and the outer curved edges 25 of the baffles 21 are provided with notches 27, portions of the high pressure air pipes 13 extending through the notches of the baffles 22 and portions of the oxygen pipes 20 extending through the notches of the baffles 21.

By referring to Figs. 2 and 3 it will be noted that the arrangement of the inner portions of the high pressure air pipes 13 is such that a well is provided vertically and centrally within the bank of high pressure air pipes, and in order to block off this well so that nitrogen may not short-circuit therethrough, an elongated bag 28, formed of canvas or other suitable material, which is filled with rockwool or other suitable insulating material, is disposed in said bag. The bag 28 is formed of a flexible material, such as canvas, so that it may adjust itself to the inner portions of the high pressure air pipes and thus effectively seal off the well in which it is arranged. The bag may be supported in any suitable manner, or the contact thereof with the high pressure air pipes may be relied on for the support of said bag.

From the foregoing, and from the drawings forming a part of this specification, it is thought that the operation of the improved heat exchanger will be obvious, the nitrogen entering the apparatus by way of the inlet conductor 6 and passing tortuously in an upward direction through the housing, in contact with the high pressure air pipes 13, for discharge from the apparatus by way of the outlet conductor 8. Also, the oxygen passes into the apparatus by way of the inlet conductor 17 and passes upwardly through the pipes 20 for discharge from the apparatus by way of the outlet conductor 18, while the high pressure air passes into the apparatus by way of the inlet conductor 10 and passes downwardly through the pipes 13 for discharge from the apparatus by way of the outlet conductor 12. In the operation of the particular apparatus illustrated in the drawings the high pressure air will enter the apparatus at room temperature and leave the apparatus at from -120°C. to -185°C. , while the nitrogen and the oxygen will enter the apparatus at from -185°C. to -170°C. and will leave the apparatus at room temperature. These temperature figures are approximate as during existence of different conditions there may be some variance in connection with the incoming and outgoing temperatures of the mediums passing through the apparatus.

The length and form of pipes provide a maximum of heat exchange in as small a diameter and as short a height as possible, thereby conserving on material and weight. Additionally, the lengths of the pipes in the various units make possible graduated temperature zones without being influenced unduly by metal mass, and the undulant form of the individual pipes allows for free expansion and contraction of said pipes, thus eliminating any tendency that expansion and contraction of the pipes would pull the ends of the pipes loose from the manifolds at their points of attachment thereto. Also, instead of removing a pipe to be repaired or replaced from the nest of pipes by rotating said pipe laterally out of the nest of pipes, as has been previously explained herein, such a pipe may be removed from the top or bottom of the apparatus.

It is pointed out that heat exchangers of the improved construction of varying capacities may

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be produced by merely employing housings of different diameters so as to permit of the employment of high pressure air pipes of greater or less number. By so increasing the capacity of the heat exchanger an apparatus of increased capacity may be provided without increasing the height of the apparatus.

We claim:

1. A heat exchanger comprising a housing having inlet and outlet means for passage of a medium into, through, and out of said housing, a pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said manifolds for passage through the manifolds and pipes of a second medium, a second pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, and a plurality of pipes arranged within said housing and connected at their opposite ends into said second pair of manifolds for passage through the second pair of manifolds and the pipes connected thereto of a third medium, each of the pipes connected to the first-mentioned pair of manifolds and each of the pipes connected to the second-mentioned pair of manifolds being provided with return bends and connecting portions between said return bends which give to the pipe a tortuous formation in the direction of the length of the pipe and said tortuous portion of the pipe being curved transversely of the pipe, said pipes connected to the first-mentioned manifolds and said pipes connected to the second-mentioned manifolds being arranged within the housing in a closely nested condition.

2. A heat exchanger comprising a housing having inlet and outlet means for passage of a medium into, through, and out of said housing, a pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said manifolds for passage through the manifolds and pipes of a second medium, a second pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, and a plurality of pipes arranged within said housing and connected at their opposite ends into said second pair of manifolds for passage through the second pair of manifolds and the pipes connected thereto of a third medium, each of the pipes connected to the first-mentioned pair of manifolds and each of the pipes connected to the second-mentioned pair of manifolds being provided with return bends and connecting portions between said return bends which give to the pipe a tortuous formation in the direction of the length of the pipe and said tortuous portion of the pipe being curved transversely of the pipe, said pipes connected to the first-mentioned manifolds and said pipes connected to the second-mentioned manifolds being arranged within the housing in a closely nested condition with the pipes which are connected to the second pair of manifolds arranged adjacent to the periphery of the nest of pipes and in curved relation with respect to the pipes connected to the first mentioned manifolds.

3. A heat exchanger comprising a housing having inlet and outlet means for passage of a medium into, through, and out of said housing, a pair of spaced apart manifolds disposed within

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said housing and provided, respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said manifolds for passage through the manifolds and pipes of a second medium, a second pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said second pair of manifolds for passage through the second pair of manifolds and the pipes connected thereto of a third medium, each of the pipes connected to the first-mentioned pair of manifolds and each of the pipes connected to the second-mentioned pair of manifolds being provided with return bends and connecting portions between said return bends which give to the pipe a tortuous formation in the direction of the length of the pipe and said tortuous portion of the pipe being curved transversely of the pipe, said pipes connected to the first-mentioned manifolds and said pipes connected to the second-mentioned manifolds being arranged within the housing in a closely nested condition, and baffle means within said housing for causing the first-mentioned medium to follow a tortuous path during its passage through the housing.

4. A heat exchanger comprising a housing having inlet and outlet means for passage of a medium into, through, and out of said housing, a pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said manifolds for passage through the manifolds and pipes of a second medium, a second pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said second pair of manifolds for passage through the second pair of manifolds and the pipes connected thereto of a third medium, each of the pipes connected to the first-mentioned pair of manifolds and each of the pipes connected to the second-mentioned pair of manifolds being provided with return bends and connecting portions between said return bends which give to the pipe a tortuous formation in the direction of the length of the pipe and said tortuous portion of the pipe being curved transversely of the pipe, said pipes connected to the first-mentioned manifolds and said pipes connected to the second-mentioned manifolds being arranged within the housing in a closely nested condition, the arrangement of the nested pipes within the housing being such that a well is formed centrally and longitudinally of the bank of pipes, and means for blocking said well.

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5. A heat exchanger comprising a housing having inlet and outlet means for passage of a medium into, through, and out of said housing, a pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said manifolds for passage through the manifolds and pipes of a second medium, a second pair of spaced apart manifolds disposed within said housing and provided respectively with inlet and outlet means, a plurality of pipes arranged within said housing and connected at their opposite ends into said second pair of manifolds for passage through the second pair of manifolds and the pipes connected thereto of a third medium, each of the pipes connected to the first-mentioned pair of manifolds and each of the pipes connected to the second-mentioned pair of manifolds being provided with return bends and connecting portions between said return bends which give to the pipe a tortuous formation in the direction of the length of the pipe and said tortuous portion of the pipe being curved transversely of the pipe, said pipes connected to the first-mentioned manifolds and said pipes connected to the second-mentioned manifolds being arranged within the housing in a closely nested condition, the arrangement of the nested pipes within the housing being such that a well is formed centrally and longitudinally of the bank of pipes, means for blocking said well, and baffle means within the housing for causing the first-mentioned medium to follow a tortuous path during its passage through the housing.

6. A heat exchanger comprising a housing having an inlet and an outlet for passage of a medium into, through, and out of said housing, a group of pipes arranged within said housing, inlet and outlet means into which the opposite ends of said group of pipes are connected for passage through said pipes of a second medium, a second group of pipes arranged within said housing, inlet and outlet means into which the opposite ends of said second group of pipes are connected for passage through said second group of pipes of a third medium, each pipe of the first-mentioned group of pipes and each pipe of the second-mentioned group of pipes being provided with continuously connected return bends which give to the pipe a tortuous formation in the direction of the length of the pipe and the pipes of the first-mentioned group of pipes being curved transversely of the pipes, the first-mentioned group of pipes and the second-mentioned group of pipes being arranged within the housing in closely nested relation.

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