Nov. 27, 1956 T. H. POLAD 2,772,077

TUBE ENVELOPING PLATE CONDENSER HAVING ROLLED ENDS, AND METHOD OF ITS CONSTRUCTION

Filed March 15, 1951 5 Sheets-Sheet 1

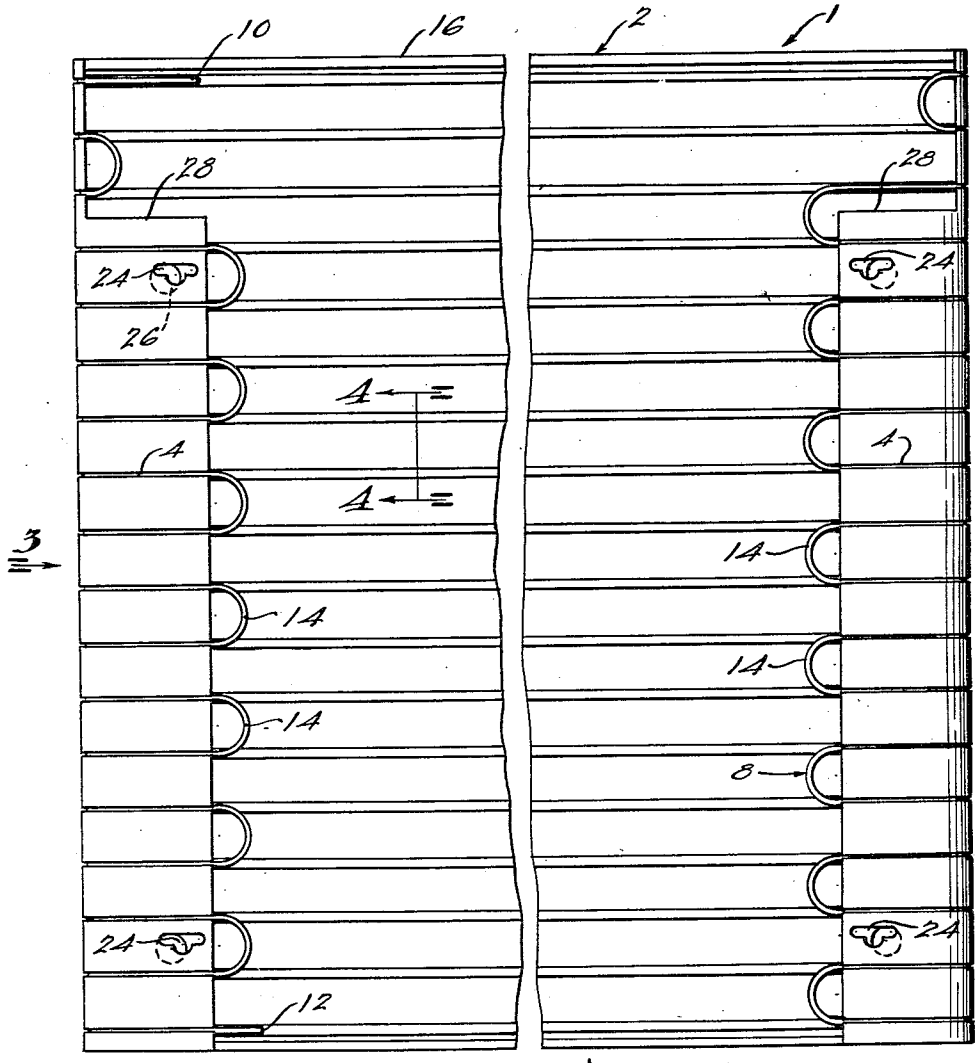

Fig. 1.

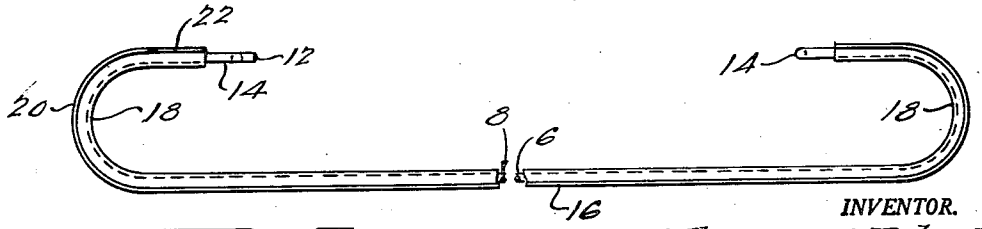

Fig. 2.

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Nov. 27, 1956 T. H. POLAD 2,772,077

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Filed March 15, 1951 5 Sheets-Sheet 2

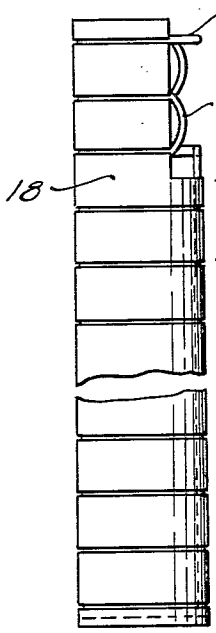

FIG. 3.

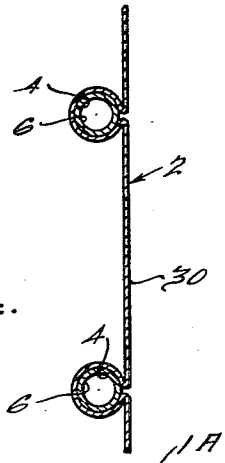

FIG. 4.

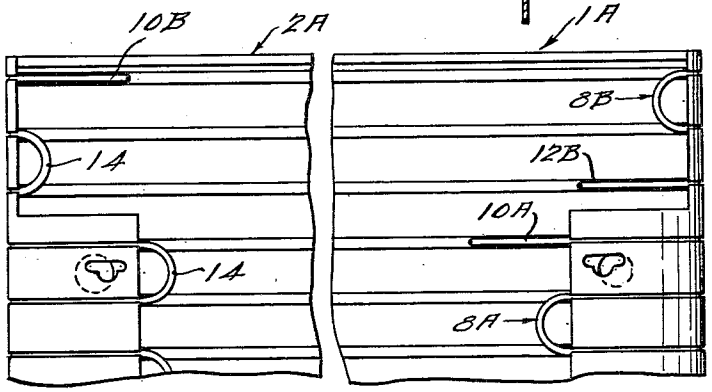

FIG. 5.

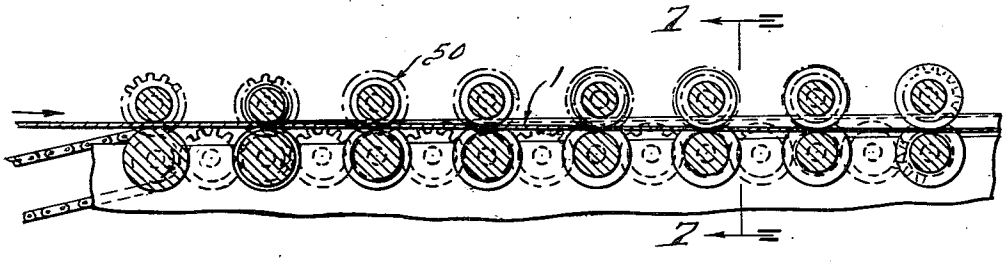

FIG. 6.

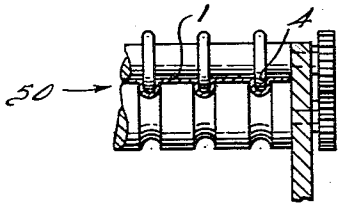

FIG. 7.

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Nov. 27, 1956 T. H. POLAD 2,772,077

TUBE ENVELOPING PLATE CONDENSER HAVING ROLLED ENDS, AND METHOD OF ITS CONSTRUCTION

Filed March 15, 1951 5 Sheets-Sheet 3

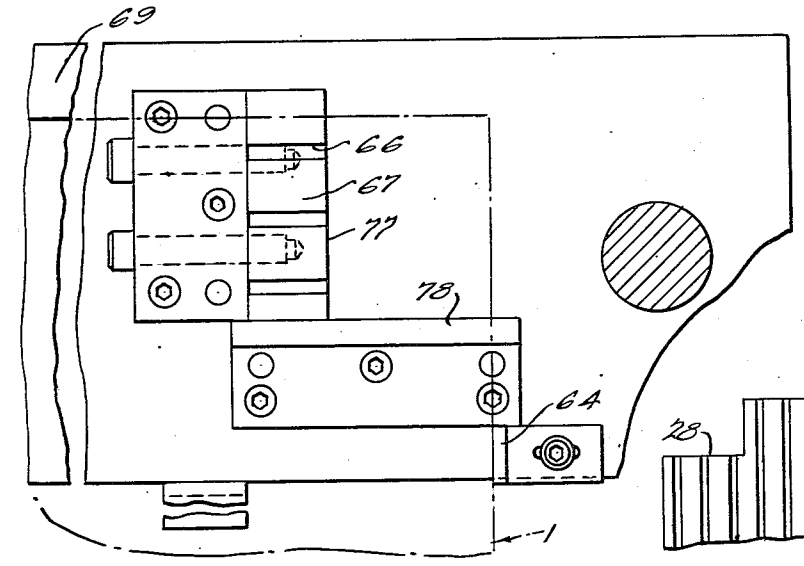

FIG. 9.

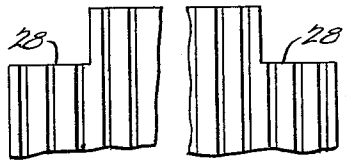

FIG. 8.

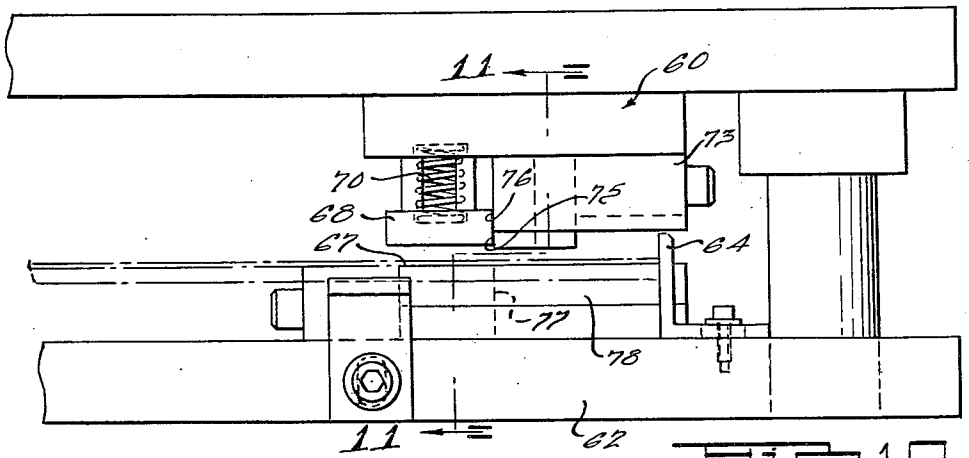

FIG. 10.

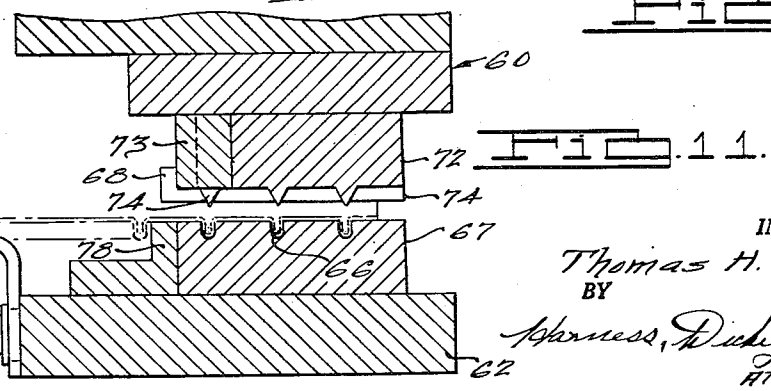

FIG. 11.

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Nov. 27, 1956 T. H. POLAD 2,772,077

TUBE ENVELOPING PLATE CONDENSER HAVING ROLLED ENDS, AND METHOD OF ITS CONSTRUCTION

Filed March 15, 1951 5 Sheets-Sheet 4

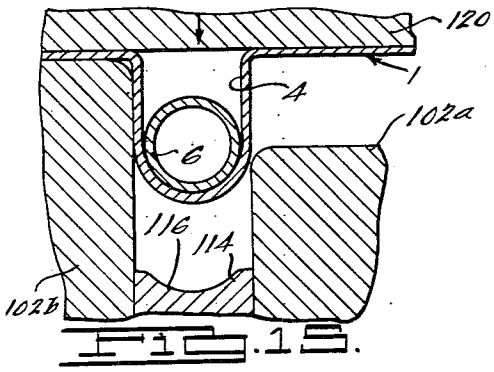

Fig. 15.

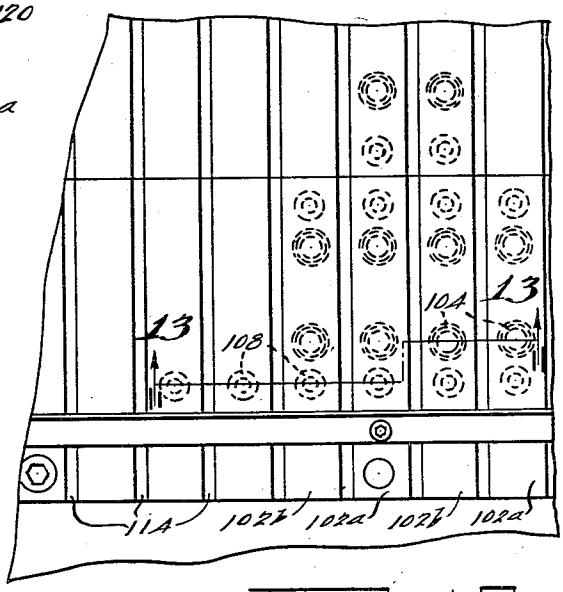

Fig. 12.

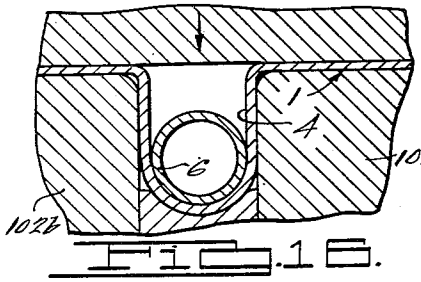

Fig. 16.

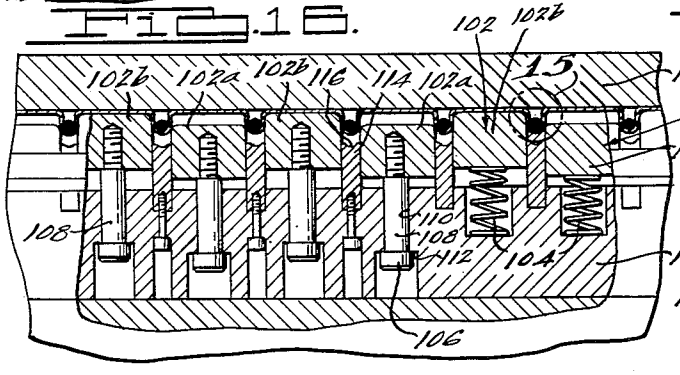

Fig. 13.

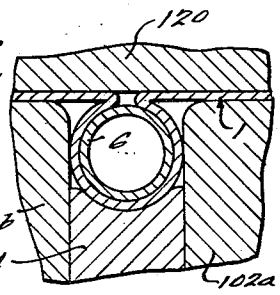

Fig. 17.

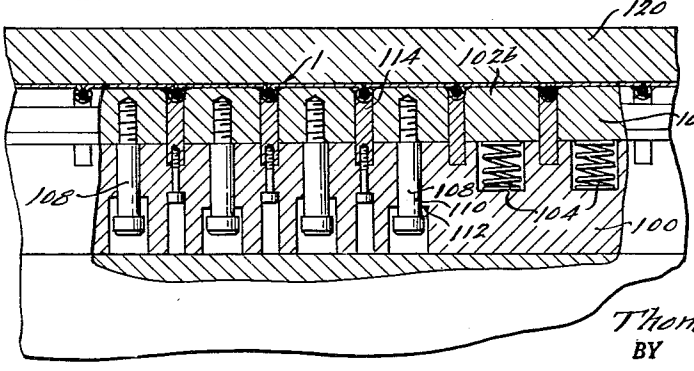

Fig. 14.

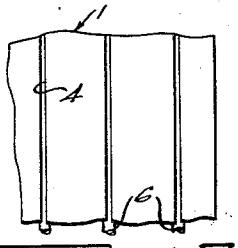

Fig. 18.

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TUBE ENVELOPING PLATE CONDENSER HAVING ROLLED ENDS, AND METHOD OF ITS CONSTRUCTION

Filed March 15, 1951 5 Sheets-Sheet 5

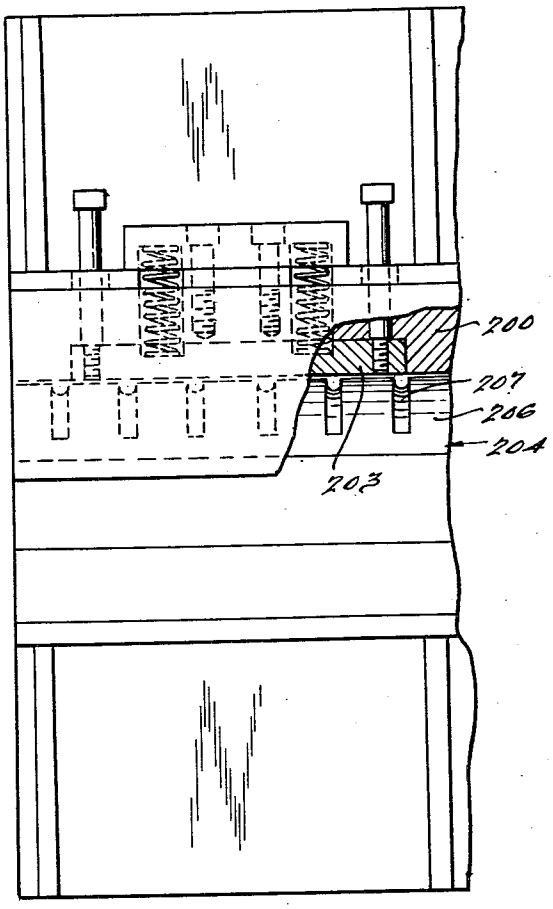

Fig. 1B.

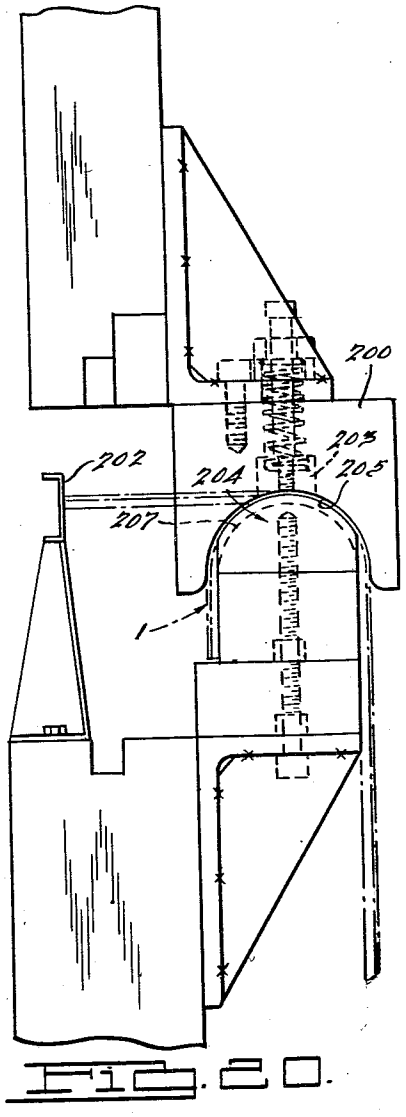

Fig. 2C.

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United States Patent Office 2,772,077 Patented Nov. 27, 1956

2,772,077

TUBE ENVELOPING PLATE CONDENSER HAVING ROLLED ENDS, AND METHOD OF ITS CONSTRUCTION

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Application March 15, 1951, Serial No. 215,822

3 Claims. (Cl. 257—256)

This invention relates generally to heat exchangers and the method of making the same and more particularly to a condenser having rolled ends and the method of its construction.

An object of this invention is to provide an improved heat exchanger of the character described.

Another object is to provide such an exchanger which is efficient in operation and economical to manufacture.

Another object of this invention is to provide such an exchanger in which there is high rate of heat transfer between the fluid conveying conduit and the radiating surfaces.

Another object of this invention is to provide such a heat exchanger which eliminates the necessity for the laborious task of soldering or brazing the fluid conveying tubing to the radiating sheet material.

Another object of this invention is to provide such a heat exchanger in which the radiating plate material substantially completely surrounds and protects the fluid conveying conduit.

Another object of this invention is to provide such a heat exchanger in which the tubing may be secured to the sheet material member in a substantially planar state and which assembled tubing and sheet member may thereafter be formed to provide at least portions of four walls of a fluid conveying chimney.

Another object of this invention is to provide such a heat exchanger in which the portions of engagement between the tubing and sheet material member are substantially straight and all of the curved portions of the conduit member are external to the sheet material member.

Another object of this invention is to provide such a chimney forming heat exchanger in which portions of the top side walls are cut away to provide for fluid flow through the chimney even though the top opening may be otherwise restricted.

A further object of this invention is to provide a new and improved method for making such heat exchanger.

Another object of this invention is to provide a method for making such an exchanger in which the operation of securing the tubing to the sheet metal member may be easily and economically accomplished.

Another object of this invention is to provide such a securing method which may be accomplished in a pressing operation.

Another object of this invention is to provide a novel method for wrapping a sheet material member substantially completely around a second elongated member to provide a tight mechanical joint therebetween.

Another object of this invention is to provide a new and novel method of wrapping an otherwise planar sheet material member about a tubular conduit.

Other objects of this invention will be apparent from the specification, the appended claims, and the drawings, in which drawings:

Figure 1 is a rear view in elevation of a condenser embodying the invention;

Fig. 2 is a lower end view of the condenser of Fig. 1;

Fig. 3 is a left-hand side view of the condenser of Fig. 1;

Fig. 4 is a fractional view of the condenser taken substantially along the lines 4—4 of Fig. 1;

Fig. 5 is a fractional view similar to Fig. 1 showing a modified form of the condenser embodying the invention;

Fig. 6 is a view partially in section showing the method for initially rolling the grooves in the sheet material;

Fig. 7 is a fractional view taken substantially along the lines 7—7 of Fig. 6;

Fig. 8 is a partial view in plan of the sheet metal structure at an intermediate step in the process of manufacture showing the sheet material member with the V grooves rolled therein and showing the notched out corner portions for providing the escape vents;

Fig. 9 is a partial view in top plan of the lower shearing die for cutting out the notched portions shown in Fig. 8;

Fig. 10 is a partial view in elevation showing both notching dies;

Fig. 11 is a view taken substantially along the lines 11—11 of Fig. 10;

Fig. 12 is a plan view showing the bottom die used for wrapping the sheet metal about the tubing within the grooves;

Fig. 13 is a view taken substantially along the lines 13—13 of Fig. 12 and showing the dies and sheet material with the press in a position just subsequent to the engagement of the top die with the workpiece;

Fig 14 is a view similar to Fig. 13 but showing the die in a final or closed position with the sheet material wrapped about the tubing;

Fig. 15 is an enlarged fragmentary view within the dot-dash circle 15 of Fig. 13 showing the tubing within the grooves of the sheet metal member at the start of the operation for wrapping the sheet metal about the tubing;

Fig. 16 is a view similar to Fig. 15 but showing an intermediate step in the process of wrapping the sheet material about the tubing;

Fig. 17 is a view similar to Fig. 16 but showing the closed position of the dies with the sheet material wrapped substantially completely about the tubular member;

Fig. 18 is a partial view in plan of the sheet metal member after it has been wrapped around the tubing;

Fig. 19 is a partial view in elevation with portions shown in section showing the die for rolling the end of portions of the heat exchanger; and

Fig. 20 is an end view of the end rolling die showing a portion of the heat exchanger therein in dot-dash lines.

Generically, this invention is directed toward a sheet metal heat exchanger and its method of manufacture which among other uses may be used as a refrigeration condenser and attached to an external wall of the refrigerated cabinet for providing a natural draft fluid flow chimney by which the heat from the condensing unit may be radiated into the ambient atmosphere.

More specifically, the condenser 1 comprises a sheet metal member 2 which has been provided with a plurality of transversely extending grooves 4 in which are positioned horizontally extending portion 6 of a generally vertically leading endless conduit 8 having an inlet end 10 and an outlet end 12. The conduit 8, in the form shown, comprises a single piece of tubing in which the plurality of horizontally extending portions embedded in the grooves 4 of the sheet metal member 2 are connected together by return bends 14. The sheet metal member 2 is preferably of one piece construction and comprises a substantially planar main or wall portion 16 and laterally extending side portions 18. These side

portions 18 preferably may be and are shown as rebent side portions of the sheet metal member 2 which provide a substantially semi-cylindrical portion 20 and a short substantially planar portion 22 which extends in a plane parallel to but spaced from the plane of the main portion 16. The portions 22 may be provided with suitable apertures 24 for receiving securing bolts 26 by which the condenser 1 may be attached to the refrigerator cabinet with which it is associated.

The condenser 1 is often secured to the rear wall of a refrigerator cabinet, such as the conventional domestic electric refrigerator, which when used is often located underneath an overhanging cupboard or shelf which might tend to restrict fluid flow upwardly therethrough and out its upper open end. For this reason, the upper end portions of the planar portions 22 and adjacent portions of the semi-cylindrical portions 20 are cut away to provide side openings or notches 28 in the laterally extending walls 18 to permit flow of fluid outwardly therethrough from the interior of the chimney-type evaporator 1.

As will be seen in Fig. 4, the sheet metal member 2 is wrapped substantially completely around the conduit portions 6 in a manner to form a tight mechanical connection therebetween which does not require soldering or brazing and to provide a pleasing appearing substantially planar exterior wall 30 for the evaporator 1. The substantially completely wrapping of the sheet metal member 2 about the tubing 6 provides a maximum of heat transfer surface therebetween. Also, since the tubing 6, in many instances, is of a softer material than that of the sheet material 2, the sheet material 2 acts as a mechanical reinforcement for the walls of the tubing 6.

In Fig. 5 there is shown a modified form of evaporator 1A in which a single sheet material member 2A is provided with a plurality of independent continuous conduits 8A and 8B which are provided with inlets 10A and 10B respectively and outlets. The outlet for the conduit 8A is not shown while the outlet for the conduit 8B is shown at 12B. The relative amounts of the sheet metal material 2 with which the conduits 8A and 8B are associated and the consequent lengths of the conduits 8A and 8B may be varied in any desired proportion depending upon the relative amounts of, and the temperature of, the heat to be radiated from the systems to which they are connected.

The novel preferred method of manufacturing the foregoing described evaporator 1 is described below with reference to Figs. 6 through 20.

Referring to Fig. 6, a strip of sheet metal, of any desired length and of a width equal to the height of the desired evaporator 1, may be suitably fed through a series of corrugating work rolls 50 which will progressively form a series of depressions in the sheet metal resulting in the grooves 4. After the grooves 4 have been formed in the sheet metal, it is cut to proper lengths in suitable shearing dies not shown to provide a length of metal which is equal to the developed width of the sheet metal 2. A preferred method is to cut the flat sheet metal to the developed width and to corrugate such cut lengths since flat metal is more easily sheared and requires no expensive dies. Subsequently the sheet of the desired dimension is inserted in the notching die to have two opposite corner portions cut away to provide notches 28.

Figs. 9, 10 and 11 show a portion of such punch and die set which will cut away the upper corners to provide the notches 28 as shown in Fig. 8. Preferably the punch and die set comprises an upper movable punch 60 and a lower die 62 which have spaced cutting or shearing portions spaced apart the desired distance to shear both notches 28 at once. Since the spaced shearing portions are alike except that one is a mirror arrangement of the other, only one shearing portion is shown to simplify the disclosure. If various sized evaporators are to be made, the right and left shearing portions could be relatively movable or could be in separate presses and the right and left notches could be sheared in separate operations. The particular arrangement actually used will depend upon the relative economies of labor and tooling costs.

The illustrated right-hand shearing portion comprises the upper right-hand portion of the punch 60 and lower die 62. The lower die is provided with an upward extending stop 64 against which the upper end surface of the sheet metal member 2 is positioned with the grooves 4 therein lying within upwardly facing complementary grooves 66 in a pad 67 of the lower die member 62. The top end edge of the member 2 engages a stop 69 carried by the die 62 intermediate the shearing portions. The stops 66 and 69 therefore act to locate the member 2 in the punch and die set. The punch member is provided with a resiliently mounted pad 68 which, upon downward movement of the punch 60, will engage the upper surface of the sheet metal member 2 for securingly holding it to the lower die member 62. Continued downward movement of the punch 60 is permitted by resilient springs 70 which urge the pads 68 in a downward direction from the punch 60 but permit relative movement of the punch 60 subsequent to engagement of the pad 68 with the workpiece.

The punch 60 is provided with a pair of shearing blocks 72 and 73. The block 72 has a series of downwardly extending V-shaped projections 74 having an end shearing face 75 which is in the same plane as the end shearing face 76 of the main portion of the block 72. The faces 75 and 76 cooperate with an end shearing face 77 of pad 67 carried by the die 62. Upon downward movement of the punch 60 the projections 74 move down into the V grooves 4 in the sheet metal member 2 and the shearing edges or faces 75 and 76 pass downwardly closely adjacent the shearing face 77 to shear away a section of the member 2 transversely of the grooves 4. The shear block 73 cooperates similarly with a lower shear block 78 to shear the member parallel to the grooves 4 whereby a corner portion of the member 2 is cut away to form the cutout notch 28.

Subsequent to notching of the workpiece, a length of suitable tubing, which has previously been rebent upon itself a number of times to form a series spaced substantially parallel extending portions connected at their end portions by rebent portions to provide the conduit portions 6 and 14, is laid within the V-shaped grooves 4. The assembly so made is then placed in another press on top of the lower die member 100 thereof substantially as shown in Fig. 13.

The lower die member 100 is provided with a plurality of movable die blocks 102 extending substantially completely across the die and which are urged upwardly by means of springs 104. Upward movement thereof is limited by engagement of the heads 106 of screws 108 which are screw-threaded into the die blocks 102 and extend downwardly through the lower die in apertures 110. The lower end portions of the apertures 110 are of enlarged diameter for receiving the head 106 and providing a shoulder 112 against which the upwardly facing shoulder of the head 106 engages to limit upward movement of the die blocks 102. Intermediate each of the die blocks 102, the lower die 100 carries a fixed die block 114 having an upwardly facing concave surface 116 which is substantially the contour to which the sheet metal is to be formed about the conduit.

Originally the grooves 4 as rolled in the sheet metal member by the rolls 50 provide a depression which is somewhat larger than the outer dimension of the conduit or tubing so that it may easily be placed within the groove 4. The spacing between the movable die blocks 102 is substantially that of the outer diameter of the sheet metal member when wrapped tightly to the conduit or tubing as shown in Figs. 16 and 17. The grooves

4 as initially formed by the rolls **50**, are of somewhat greater width than the space between the movable die blocks **102**. The die blocks **102** are therefore arranged in two alternating groups of blocks **102***a* and **102***b*. The blocks **102***a* are arranged to have less upward movement and normally held at a lower level than the blocks **102***b*.

When the member **2** is initially placed in the die **100** it rests in the die blocks **102***b* with the grooves **4** extending partially into the space between the blocks **102***a* shown in Figs. 13 and 15. As the upper die **120**, which has a planar lower surface, moves downwardly, the upwardly-most set of the movable die blocks **102** will move downward therewith moving the grooves **4** down into the spaces between the die blocks **102** toward the fixed die blocks **114**. This forces the grooves **4** into these narrower spaces pressing them tightly about the lower half of the conduit. At the time the upper die **120** has moved the workpiece so that it engages the top surface of the lowerly positioned die blocks **102***a*, the lower end surface of the grooves **4** will be in engagement with the upper concave surfaces **116** of the fixed die blocks **114**. The force exerted by the springs **104** on the die blocks **102***a* is sufficient to hold the blocks **102***a* against downward movement and to wrap the sheet metal about the lower half of the conduits. At the position shown in Fig. 16 in which the planar portion of the member **2** has just engaged the blocks **102***a*, the blocks **102***a* are still in this uppermost position. Continued downward movement of the upper die **120** will force the movable die blocks **102** downward but since the bottom end of the groove **4** is already engaging the upper surface of the fixed die blocks **114**, the excess metal in the upper leg portions of the groove **4** will be pushed about the surface of the conduit and when the press has been fully closed, as shown in Fig. 14, the metal will have wrapped itself around the tubing substantially as shown in Fig. 17.

Up to this time the sheet metal member is in substantially planar form and ready to have its side edges rolled in the rolling dies shown in Figs. 19 and 20. Initially the upper die **200** is in an upper position to permit the sheet metal member **2** to be placed therein with the side edge in engagement with a longitudinally extending stop **202**. The upper die is then moved down by suitable mechanism to move the resiliently supported clamping pad **203** to clamp the member **2** against the lower die **204**. Continued downward movement moves the lower concave substantially semi-cylindrical surface **205** of the die **200** downwardly to wrap the side edge of the sheet metal member **2** about the lower upwardly facing convex substantially semi-cylindrical surface **206** of the fixed die **204**. In this regard it should be noted that the convex surface of said die **204** is provided with grooves **207** which receives the grooves **4** of the sheet member **2** whereby the walls thereof and of the conduit **8** will be held against unwanted distortion. The dies **200** and **204** thus rebend the side edge of the condenser about itself to form the laterally extending end wall **18** comprising the semi-cylindrical portion **20** and the substantially planar portion **22**.

The apertures **24** may be made at any desired time such as concurrently with the shearing of the strip to proper dimension. While there is shown and described only limited forms of the invention, it is to be appreciated that the specific details may be varied widely and still come within the scope of my invention which is to be limited only by the scope of the hereinafter appended claims.

What is claimed and is desired to be secured by United States Letters Patent is as follows:

1. In a plate-type heat exchanger, a sheet metal member formed to provide a substantially main planar portion, and rebent curved side members extending laterally from the plane of said main portion and into a plane spaced from the plane of said main portion, said portions in said spaced plane being provided with means for securing such exchanger to a vertical surface, said sheet metal member being deformed to provide spaced substantially parallel channels extending laterally completely across said sheet metal member inwardly from the outer surface thereof to provide flat webs therebetween, an endless conduit having spaced portions positioned within said channels and U-shaped portions connecting said spaced portions and positioned in spaced relation to said sheet metal member in said spaced plane, the interior walls of said channels engaging the walls of said spaced conduit portions and being formed therearound to present a smooth outer surface to said exchanger.

2. In a plate-type heat exchanger; a sheet metal member formed to provide a substantially planar main portion, and bent side members extending laterally from the plane of said main portion, said side members being provided with means for securing such exchanger to a surface with said main portion spaced therefrom, said sheet metal member being deformed to provide spaced substantially parallel channels extending laterally completely across said sheet metal member inwardly from the outer surface thereof to provide flat webs therebetween, an endless conduit having spaced portions positioned within said channels and U-shaped portions connecting said spaced portions and positioned in spaced relation to said sheet metal member in said side members, the interior walls of said channels engaging the walls of said spaced conduit portions and being formed therearound to present a smooth outer surface to said exchanger.

3. The method of making a tube and plate heat exchanger from a length of conduit and a section of substantially flat sheet metal which comprises the steps of: forming spaced trough means in said sheet metal section extending completely across one dimension thereof while maintaining flat webs disposed between the trough means and keeping said webs in a common plane, forming said conduit to have straight portions joined by end loop portions, placing the straight portions of said formed conduit in said trough means with the end loop portions extending therebeyond, of supporting the walls of said trough means against movement outwardly away from each other, confining the webs at the ends of said walls against movement out of said plane, and applying a force to said troughs to move the bottom of the trough means toward the plane of said webs and thereby collapse the walls of the trough means inwardly to cause the inner portions thereof to wrap around the periphery of the straight portion of the conduit, and limiting the movement of the outer portions of said trough walls to said plane to thereby provide a substantially continuous flat surface to one side of said exchanger.

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