April 29, 1969 W. A. COLLINS 3,440,704

METHOD OF CONSTRUCTING A CONTINUOUS TUBE FINNED HEAT EXCHANGER

Filed Dec. 26, 1967 Sheet 1 of 4

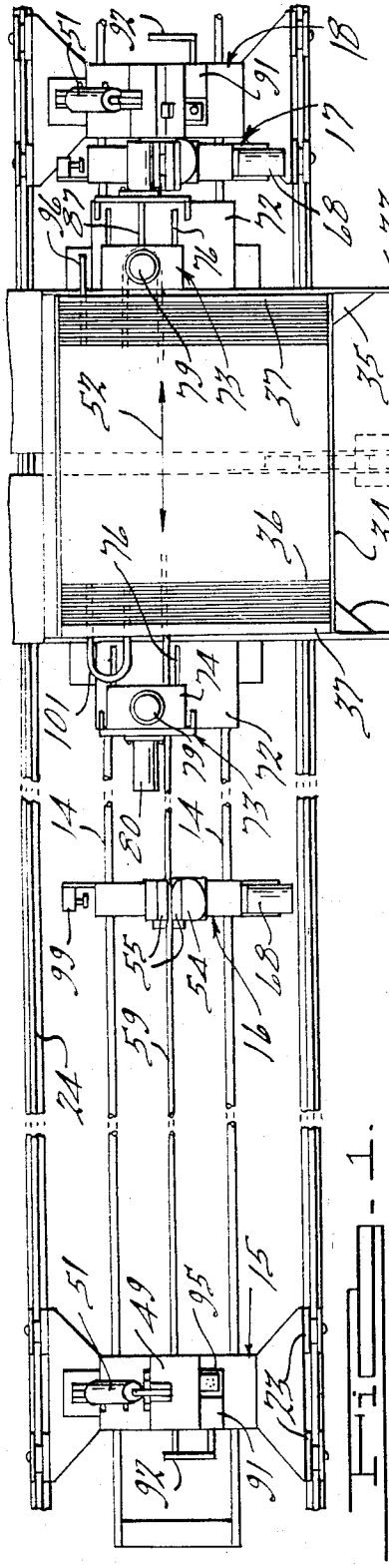


Fig. 1.

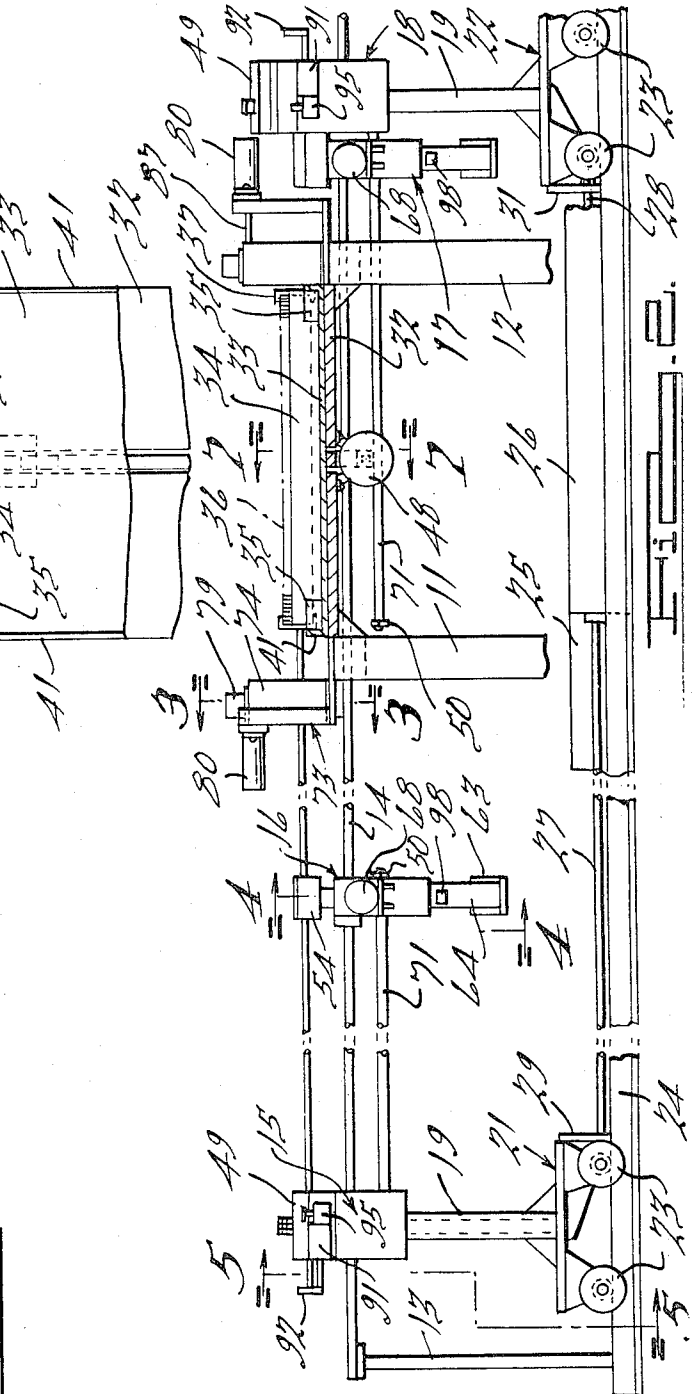


Fig. 2.

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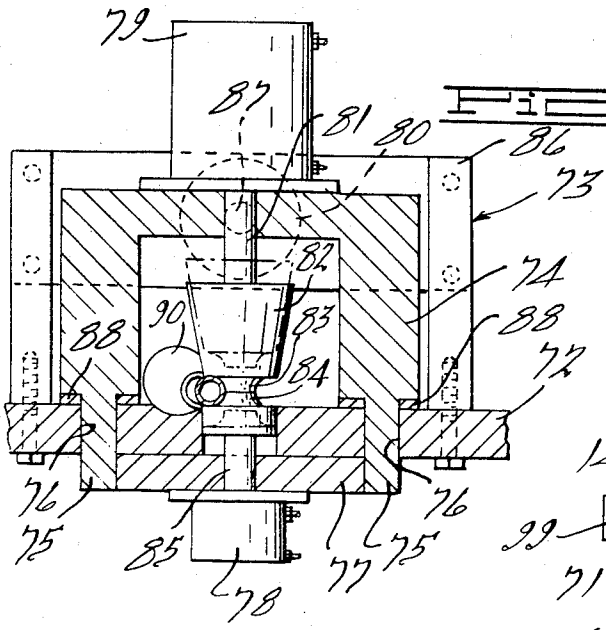


FIG. 3.

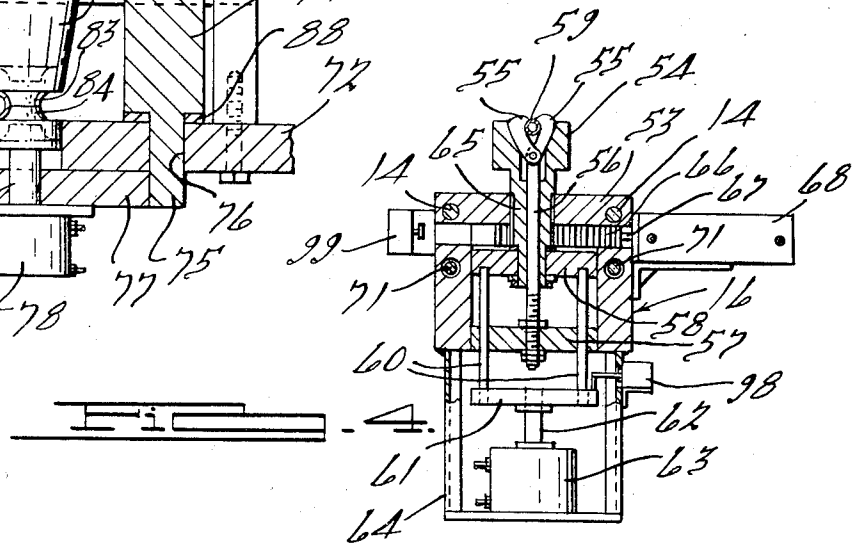


FIG. 4.

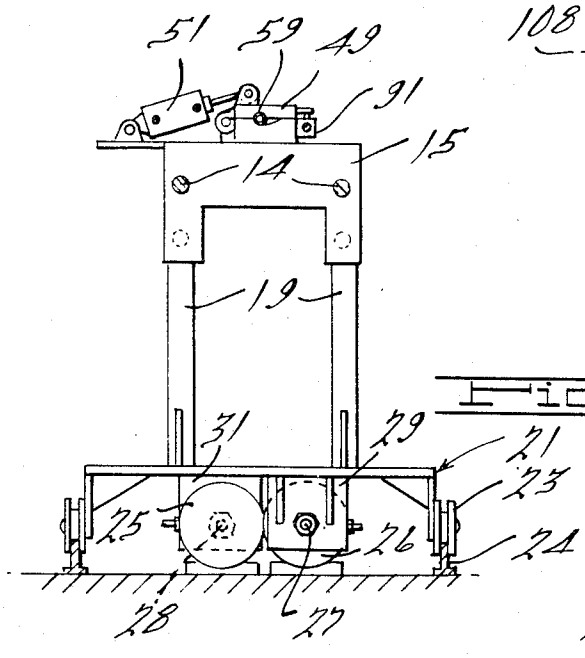


FIG. 5.

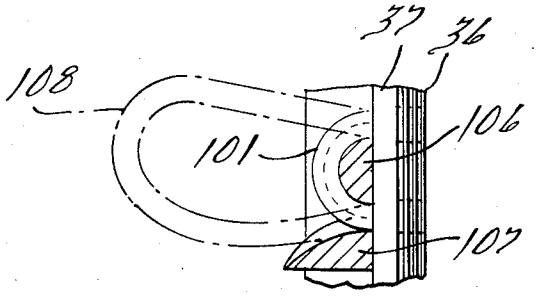


FIG. 6.

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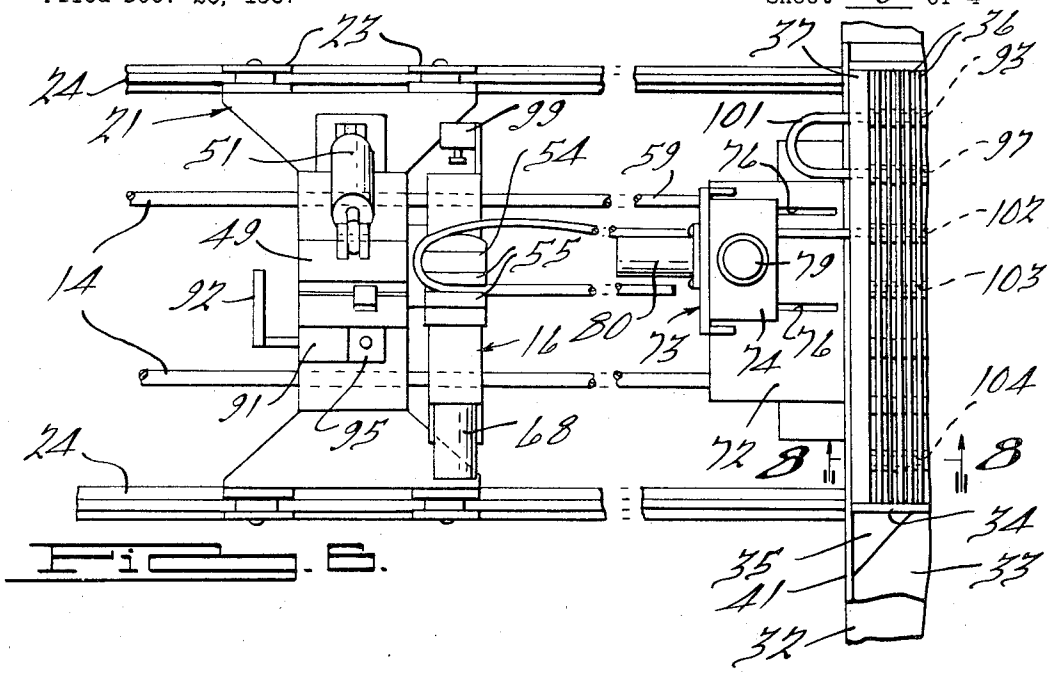


Fig. 6.

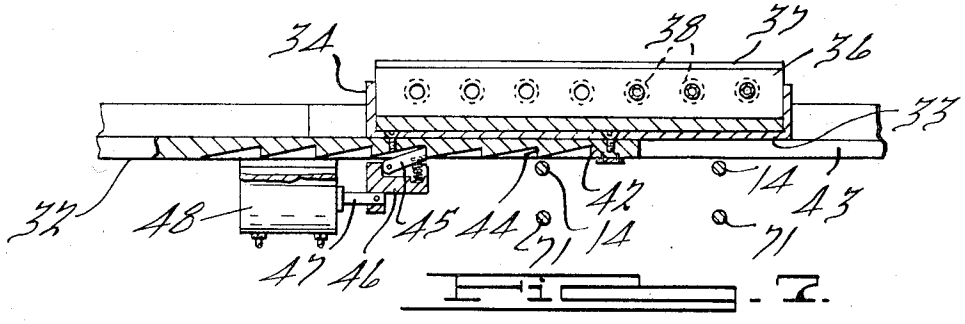


Fig. 7.

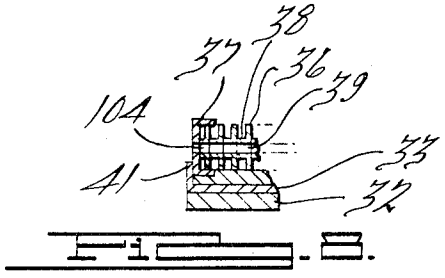


Fig. 8.

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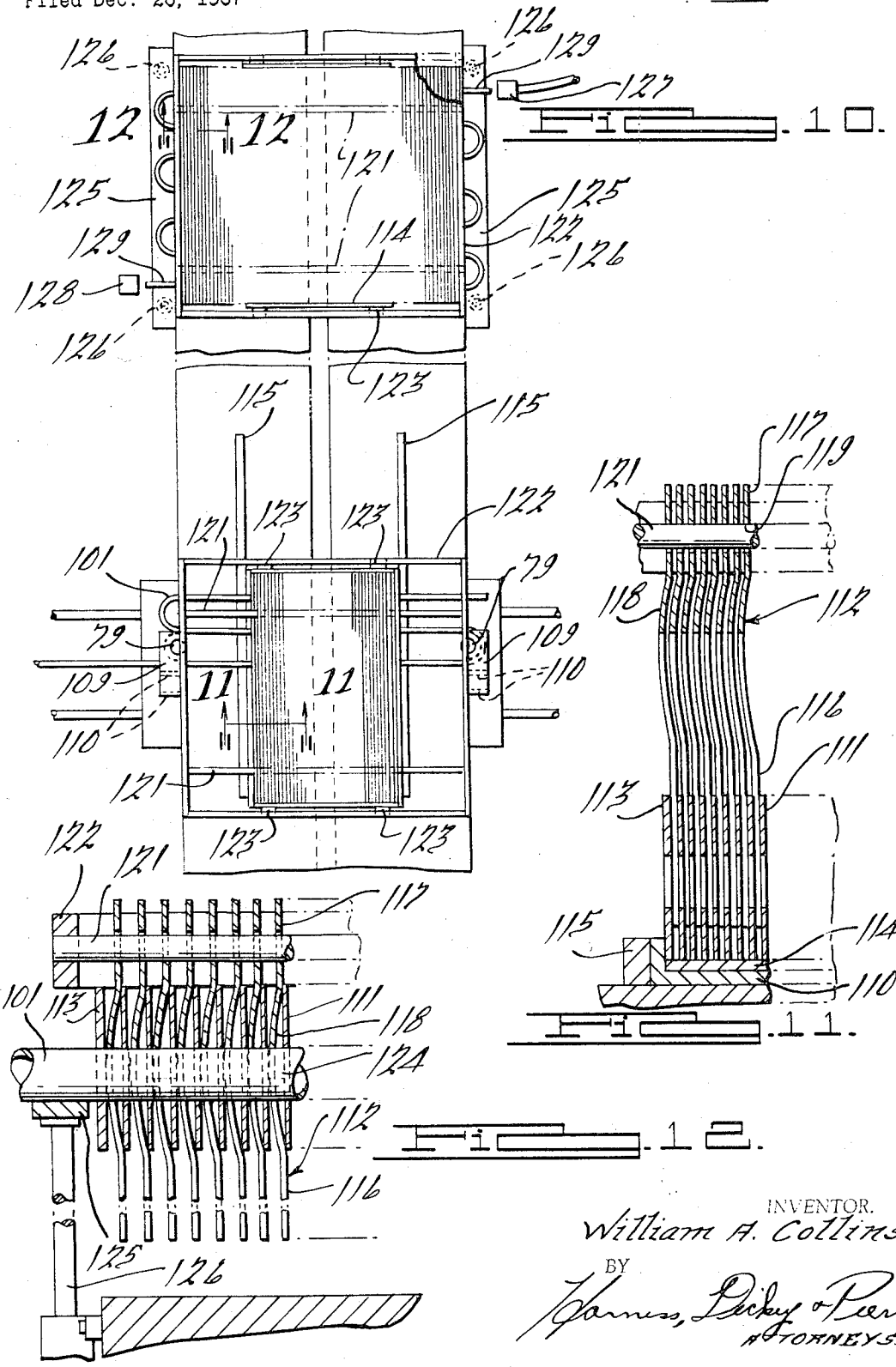


FIG. 10.

FIG. 11.

FIG. 12.

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METHOD OF CONSTRUCTING A CONTINUOUS TUBE FINNED HEAT EXCHANGER

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Int. Cl. B23p 15/26, 25/00
U.S. Cl. 29—157.3 10 Claims

ABSTRACT OF THE DISCLOSURE

The method pertains to the threading of a continuous tube of conducting material back and forth through a stack of fins having a plurality of apertures which are in aligned relation to form a plurality of through openings. The tube is inserted through the first opening, reversed, advanced and pulled through the second opening forming a loop. The tube is again reversed and advanced and pulled through a third opening forming another loop and so on until all of the openings have straight tube sections extending therethrough with oppositely disposed loops on the ends forming a continuous sinuous tubular path. The loops are either drawn toward the fins or the fins are moved apart towards the loops.

Background of the invention

There was no art uncovered which disclosed the method of so threading a continuous tube through a plurality of openings formed by aligned apertures in the fins.

Summary of the invention

The stacked fins and end elements with the apertures aligned forming a plurality of through openings are placed in a tray which is periodically advanced to align the openings seriatim along the center of the machine where the tube is pushed and pulled through the openings to form loops on the ends. Similar devices are employed on opposite ends of the machine to push and pull the tube through an opening on the center of the devices. The pulling device is moved a substantial distance because of the substantial length of the tube when drawn through the first opening. The distance the pulling devices must move can be substantially shortened by inserting the tube at the center of the stack of fins and end elements and thread the tube through the opening toward one side after which the stack can be turned over so that the other end of the inserted tube can be threaded through the openings on the other side of the stack with all of the threading occurring on the center line of the machine. A reversing device is provided between the pulling device and the fins which is moved outwardly with the pulling device and spaced a predetermined distance therefrom so that a predetermined length of tube can be reversed. The reversing device is in position to grasp the tube as it is released from the pulling device and bend the tube about a mandrel forming a large loop when reversing the end length. The length is located on the machine center line so that when a stack of fins is indexed to locate the next adjacent opening on the center line, the return movement of the pulling device picks up the reversing device and moves the tube toward and through the opening a sufficient distance to have the free end in position to be engaged by the pulling device on the opposite side of the fin stack. The reversing device is unclamped and

clamping and lowered to permit the tube to be formed into an end loop.

In this manner the tube is threaded through the openings of the stack to have straight portions extending through the fins with oppositely disposed loops on the ends. The loops are either drawn close to the fins or the fins are spread apart to engage the loops after which pressure is provided within the tube to cause the expansion thereof and to provide a 360° contact with the edge of the apertures through the fins and end elements. The ends of the tubes are cut off to provide short sections, when the tube is made of aluminum or like material which is difficult to braze or otherwise attach to the conduits of a heat exchange system, and a short section of copper tube attached thereto.

Brief description of the drawings

FIGURE 1 is a broken plan view of a machine for practicing the method of the present invention;

FIG. 2 is a side view of the machine illustrated in FIG. 1;

FIG. 3 is an enlarged sectional view of the structure illustrated in FIG. 2, taken on the line **3—3** thereof;

FIG. 4 is an enlarged sectional view of the structure illustrated in FIG. 2, taken on the line **4—4** thereof;

FIG. 5 is an en enlarged sectional view of the structure illustrated in FIG. 2, taken on the line **5—5** thereof;

FIG. 6 is an enlarged broken view of the structure illustrated in FIG. 1, showing the end section of the tube reversed;

FIG. 7 is an enlarged broken sectional view of the structure illustrated in FIG. 2, taken on the line **7—7** thereof;

FIG. 8 is an enlarged broken sectional view of a portion of the structure illustrated in FIG. 6, taken on the line **8—8** thereof;

FIG. 9 is a view of loop forming structure, similar to that illustrated in FIG. 1, showing another form of the invention;

FIG. 10 is a view of structure, similar to that illustrated in FIG. 1, showing a further form of the invention;

FIG. 11 is an enlarged broken sectional view of the structure illustrated in FIG. 10, taken on the line **11—11** thereof showing the fins in adjacent relation, and

FIG. 12 is an enlarged broken sectional view of the structural illustrated in FIG. 10, taken on the line **12—12** thereof, showing the fins in spaced relation.

Description of the preferred embodiments

A machine for practicing the present method is illustrated in FIGS. 1 to 8. The machine has central uprights **11** and **12** and supporting posts **13** at each end. The post and uprights support a pair of guide rods **14** on which pulling devices **15** and **18** and reversing devices **16** and **17** are slidably mounted on opposite sides of the uprights **11** and **12** respectively. The pulling devices **15** and **18** are mounted on upright channels **19** which are supported on carriages **21** and **22** having wheels **23** thereon which run upon a pair of tracks **24**. A pair of cylinders **25** and **26** are supported between the tracks having piston rods **27** and **28** extending therefrom and connected to plates **29** and **31** which are attached to the carriages **21** and **22**.

The uprights **11** and **12** support a platform **32** on which

a slide 33 is mounted for incremental movement. A tray 34 rests upon the slide 33 and abuts a pair of stop elements 35. A stack of fins 36 with end channels 37 are mounted within the tray and accurately spaced from each other by collars 38 about the apertures through the fins. The apertures are aligned forming a plurality of openings 39 through the stack which extend above the end flanges 41 of the slide 33.

As illustrated more specifically in FIG. 7, the bottom of the tray has a bar 42 attached thereto which mates with a slot 43 in the plaform 32. The bar 42 has teeth 44 extending downwardly therefrom actuated by a pawl 45 carried by a head 46 on a piston rod 47 extending from a cylinder 48 which is attached to the bottom of the platform 32. The pull heads 15 and 18 have a clamping jaw 49, each of which is actuated by a cylinder 51 to open and closed positions. When the jaws are in open position the end of the tube may be swung away therefrom in a horizontal plane. The jaws 49 on the pull devices 15 and 18 are in aligned relation on the center of the machine which is indicated by a line 52 having arrows at each end.

The reversing device 16 and 17 are illustrated in FIG. 4 as having a head 53 mounted on the rods 14. The head 53 has a rotatable jaw 54 carrying clamping fingers 55 which are pivotally mounted on a rod 56 which is supported on a cross member 57 carried by the head 53 for rotative movement relative thereto. The jaw 54 is rotatably supported on a cross head 58 carried on a pair of rods 60 on a plate 61 which is attached to a piston rod 62 actuated by a ram 63 supported on a U-shaped bracket 64 attached to the head 53. The jaw 54 has a gear section 65 with the teeth thereof in mesh with the teeth of a rack 66 actuated by a piston rod 67 from a cylinder 68. After the tube 59 has been drawn through an opening, the jaw 54 is raised to have the fingers 55 clamp the tube. Thereafter the rack 66 is operated to rotate the jaw and tube through 180°. The head 53 has a pair of rods 71 slidably extending therethrough with nuts 50 on the forward end, the opposite end being fixed to the pulling devices 15 and 18.

The platform 32 has an extension 72 at each side on which a loop forming mechanism 73 is supported. This mechanism is illustrated more specifically in FIG. 3, wherein a U-shaped frame 74 has flange extensions 75 which project through slots 76 through the platform. The extensions are interconnected by a plate 77 to which a cylinder 78 is secured. A cylinder 79 is mounted on the top web of the U-shaped element 74 having a piston rod 81 which supports a conical element 82 having an annular arcuate end 83. An element having a similar arcuate end 84 is mounted on a piston rod 85 extending from the cylinder 78. When the piston rods 81 and 85 are moved toward each other the two arcuate ends 83 and 84 form an annular recess about which the loops is formed when one end of the tube is pulled through an opening through the stack of fins and end channel elements.

A ram 80 is supported on a frame 86 secured to the platform extension 72 having a piston rod 87 which is attached to the U-shaped frame 74. A predetermined pressure is provided for resisting the movement of the frame 74 after the tube is advanced around the abutted arcuate elements 83 and 84. The frame 74 is drawn toward the slide 33 until the loop is disposed adjacent to the slide. When the arcuate ends are separated the frame 74 retracts to permit the formed loop and slide to be advanced. Bearing plates 88 may be provided on the shoulders above the platform formed at the junction of the extensions 75. An arcuate shaped guide 90 has a small end located adjacent to the arcuate ends 83 and 84 to direct the tube end into engagement therewith and into alignment with the opening. A hydraulic valve 91 is mounted on the pulling heads 15 and 18 having a plate 92 on the end in position to be engaged by the tube 59 after the tube has passed through the jaw 49.

The operation

The stack of fins 36 and end elements 37 are disposed on the tray 34 and delivered to the slide 33 in abutting relation to the stops 35. The slide had been retracted to have the first opening 93 through the stack aligned with the centerline 52 and the jaws 49 of the pulling heads 15 and 18. The end of a length of tube 59 is advanced through the first opening 93 and into the jaws 49 of the pulling head 15. When the end of the tube 59 strikes the plate 92, the valve 91 is actuated and the piston rod in the cylinder 51 moves forwardly to close the jaw 49 which tightly grasps the end of the tube. Upon the closing of the jaw 49, a switch 95 is actuated to energize the valve for supplying fluid to the right-hand end of the cylinder 26 to move the carriage 21 to the left. This movement pulls the tube 59 through the opening 93 leaving an end 96 extending from the right-hand channel element 37. During this movement the rods 14 are carried to the left by the head 15 until the nuts 50 engage the reversing device 16 and move it to the left along with the head 15. The distance between the head and device provides a length of tube which is required for inserting through the next opening 97.

When the pressure on the fluid in the cylinder 26 rises to a predetermined amount as the carriage reaches the end of its travel limit by the pull on the tube 59, a valve is actuated to cut off the fluid to the cylinder 26 and energize the ram 63. This raises the cross head 58 and the jaw 54 which clamps the fingers 55 about the tube 59. This causes a valve 98 to be operated to introduce fluid to the outer end of the cylinder 68 and advance the piston rod 67 and rack 66 to rotate the jaw 54 through 180° travel. As the jaw rotates, the end of the tube 59 is moved out of the jaw 49 of the carriage 21 and the tube section is reversed and aligned with the centerline 52 and the jaws 49. The reversing of the tube causes the turning device to be advanced by the pull on the other tube portion toward the platform 32 and energizes a valve which produces the indexing of the slide 33 and the location of the next opening 97 on the centerline 52. At the end of the turning operation, a switch 99 is energized to operate a valve to produce the lowering of the cross head 58 and a flow of fluid to the front end of the cylinder 26 to thereby move the carriage 21 to the right which will pick up the turning device 16 and move it to the right to advance the end of the tube into the opening 97 from the left-hand side thereof.

The portion of the tube extending from the opening 93 is free to move outwardly as the end of the tube is advanced to and through the opening 97 and into the jaw 49 on the carriage 22 at the right-hand side of the machine. The striking of the plate 92 by the end of the tube energizes the valve 91 and closes the jaw 49. This energizes the switch 95 which operates a valve to introduce fluid to the left-hand end of the cylinder 25 and move the carriage 22 to the right. This movement will continue until the loop is formed about the two arcuate elements 83 and 84 as the U-shaped frame 74 is moved toward the platform 32 to reduce the size of a loop 101 formed on the left-hand side of the fin assembly. As the pressure mounts at the end of the stroke, a valve will be operated to shut off the fluid to the cylinder 25 and to supply fluid to the ram 63 of the turning device 17 which is moved to the left. The ram 63 moves the crosshead 58 upwardly operating the valve 98 and advancing the rack 66 to rotate the jaw 54 through 180°. This operates the switch 99 which reverses the flow of fluid to the cylinder 25 and causes the carriage 22 and head 18 to move to the left engaging the reversing device 17. This produces the lowering of the crosshead 58 and moves the reversing device toward the platform 32 feeding the tube length through the next opening 102 until the end is passed through the jaw 49 on the carriage 21 and clamped therein.

When the frame 74 reaches the end of its travel it operates a valve (not shown) to reverse the flow of fluid to

the cylinders **78** and **79** and thereby separate the two arcuate elements **83** and **84** to permit the frame **74** to retract and the slide **33** to be indexed one step to align the next opening **103** with the centerline **52**. The operation continues in this manner of reversing a section of the tube and pushing the end through an opening, clamping the end and pulling the remainder of the tube through the opening and forming alternate loops **101** at the ends of the fin stack. After the tube **59** has been inserted through the last opening **104** the tube is expanded and the ends are cut to leave a short section extending at each side to which a short copper tube (not shown) is brazed, welded or otherwise secured when the tube **59** is made from a material difficult to braze. The ends formed by the copper tube can be easily attached to conduits in a heat exchange system.

By the use of the machine, the conducting tube is threaded back and forth through openings formed by aligned apertures through the fins with oppositely disposed loops formed at the ends of the straight portions which are expanded by pressure, mechanical means or otherwise to have the fins and straight portions of the tubes in conducting relation to each other. A pressure fluid may be employed to produce the expansion by attaching the pressure line to the conduit **96** and closing the other end of the tube. A ball with a piston therebehind may be traversed through the tube by pressure or pulled by a cable to produce the mechanical expansion of the tube wall. The latter machine and method is illustrated, described and claimed in applicant's co-pending application, Ser. No. 702,490, filed Jan. 15, 1968, for "Machine and Method of Expanding Tube Sections" which was assigned to the assignee of the present invention. It is to be understood that the machine can be foreshortened by first inserting the tube through the cenral opening **103** and threading one end through the openings located on one side thereof in the manner pointed out above, and thereafter threading the other end through the openings located on the other side thereof.

When the tube is made of a hard material which makes it difficult to have it drawn forwardly about the arcuate elements **83** and **84**, the method of FIG. 9 can be practiced. This embodies the use of two half-arcuate elements **106** disposed adjacent to the end channels **37** with a guide element **107** adjacent thereto for guiding the free end of the tube through an opening as the loop **108**, shown in dot dash line, is reduced in size about the abutted elements **106** to form the loop **101** in final position. This is made possible by supporting the cylinder **79** on the overhanging end of a plate **109** supported on one or more fixed uprights **110**, as illustrated in FIG. 10, so that when the loop **101** is released by the separation of the half elements **106**, the slide **33** can be indexed. After the two halves **106** have been separated by the movement of the piston rods **81** and **85** into the cylinders **79** and **78** the slide **33** is indexed to have the next opening aligned on the centerline **52**.

A further method of constructing the heat exchanger is illustrated in FIGS. 10 to 12 wherein the stack is composed of fins **111** which are plain strips with apertures therethrough alternately disposed with spreading combs **112** and with end plates **113** at the ends of the stack. The stack is disposed in a flanged tray **114** which is supported in a slide **110** located between plates **115**. The combs **112** are made of hard spring steel having aligned straight portions **116** and **117** and an arcuate portion **118** therebetween. A pair of apertures **119** are provided in the straight portion **117** of the combs **112** through which a pair of rods **121** extend. The rods are secured in a rectangular frame **122** which is supported on the tray by posts **123**. A tube **124** is threaded back and forth through the opening in the fins and end plates and looped about the half arcuate elements **106** with the assembly indexed after each loop is formed. Thereafter the assembly is advanced to have the loops extend over bars **125** which are supported on posts **126** on a plate and ram which raises the bars **125**, the loops and straight portions. When this occurs, the fins and end plates pass over the arcuate sections **118** of the combs **112** and are spread apart, as illustrated in FIGS. 10 and 12. The fins **111** are evenly spaced on the straight tube portions with the end plates **113** contacting the loops at the ends of the half circle form thereof. A fluid delivery plug **127** and sealing plug **128** are advanced to engage the ends **129** of the tube to pressurize the internal area of the tube by a delivered fluid which expands the tube into conducting relation with the edges of the fin apertures providing 360° contact therebetween. This engagement maintains the fins, the end plates and tube in fixed relation to each other. The expansion can be performed by other means and the conducting relationship can also be produced by brazing and the like.

It has been herein illustrated how the tube may be threaded back and forth through the openings in a stack of fins and end plates. The method embodies the formation of loops at each side of the stack from a continuous tube having straight portions extending through the openings through the stack. When there are two rows of openings the slide may be disposed at an angle so that the tube can be threaded from one row of openings to the next row to form the loops in a horizontal plane. Any position of loops may be formed from the tube to provide the desired path for the fluid to be cooled or heated. Several heat exchangers may be made continuously and stacked one upon the other by the twisting of the loop joining the different exchanger units. In any event the method provides the formation of a single row of tubes or any multiplicity thereof employing a single tube which is continuous. The method is limited only by the practical length of the tube which can be handled by the machine starting from the end or the center of the stack of fins.

What is claimed is:

1. The method of constructing a heat exchanger which includes the steps of: stacking a plurality of spaced metal fins, each fin having a plurality of apertures, with the apertures therethrough aligned to form a plurality of openings, and threading a metal tube back and forth through the openings to provide a continuous uniform passageway, said back and forth threading forming reverse bends of the tube at the ends of the fin stack.

2. The method as recited in claim **1**, wherein the tube portions within the openings are conductively joined to the fins.

3. The method as recited in claim **1**, wherein the tube portions within the openings are expanded to engage the entire rim of the apertures of the fins.

4. The method as recited in claim **1**, wherein the threading of the tube produces straight portions extending through said openings and wherein the bending of the tube back and forth during the threading operation produces oppositely presenting loops at the ends of the straight portions at opposite ends of the fin stack.

5. The method as recited in claim **1**, wherein the fins are spaced a predetermined distance apart by collars about the apertures therethrough.

6. The method as recited in claim **1**, wherein reinforcing elements are placed at the ends of the fins having apertures aligned with said openings and through which the tube is inserted during the threading operation.

7. The method as recited in claim **4**, wherein the loops and fins are moved relative to each other to space the fins relative to the loops.

8. The method as recited in claim **1**, wherein the fins are stacked with spreading combs therebetween which move the fins toward the loops and space them relative to each other upon the relative movement between the combs and fins.

9. The method of constructing a heat exchanger which includes the steps of: aligning apertures through the body of a stack of metal fins, each fin having a plurality of apertures, to provide a plurality of spaced openings; threading a continuous length of metal tubing back and forth through said openings with straight portions extend-

ing through the fins, and forming loops of the tubing at the ends of the straight portions between each back and forth threading thereof.

10. The method as recited in claim **9**, wherein a conducting relationship is produced between the surface of the tube and the entire rim of the fin apertures.

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U.S. Cl. X.R.

29—33, 202, 433; 113—118