July 2, 1968 L. E. CONKLIN 3,390,566

FIN-TUBE PANEL BENDING APPARATUS

Filed Dec. 10, 1965 6 Sheets-Sheet 1

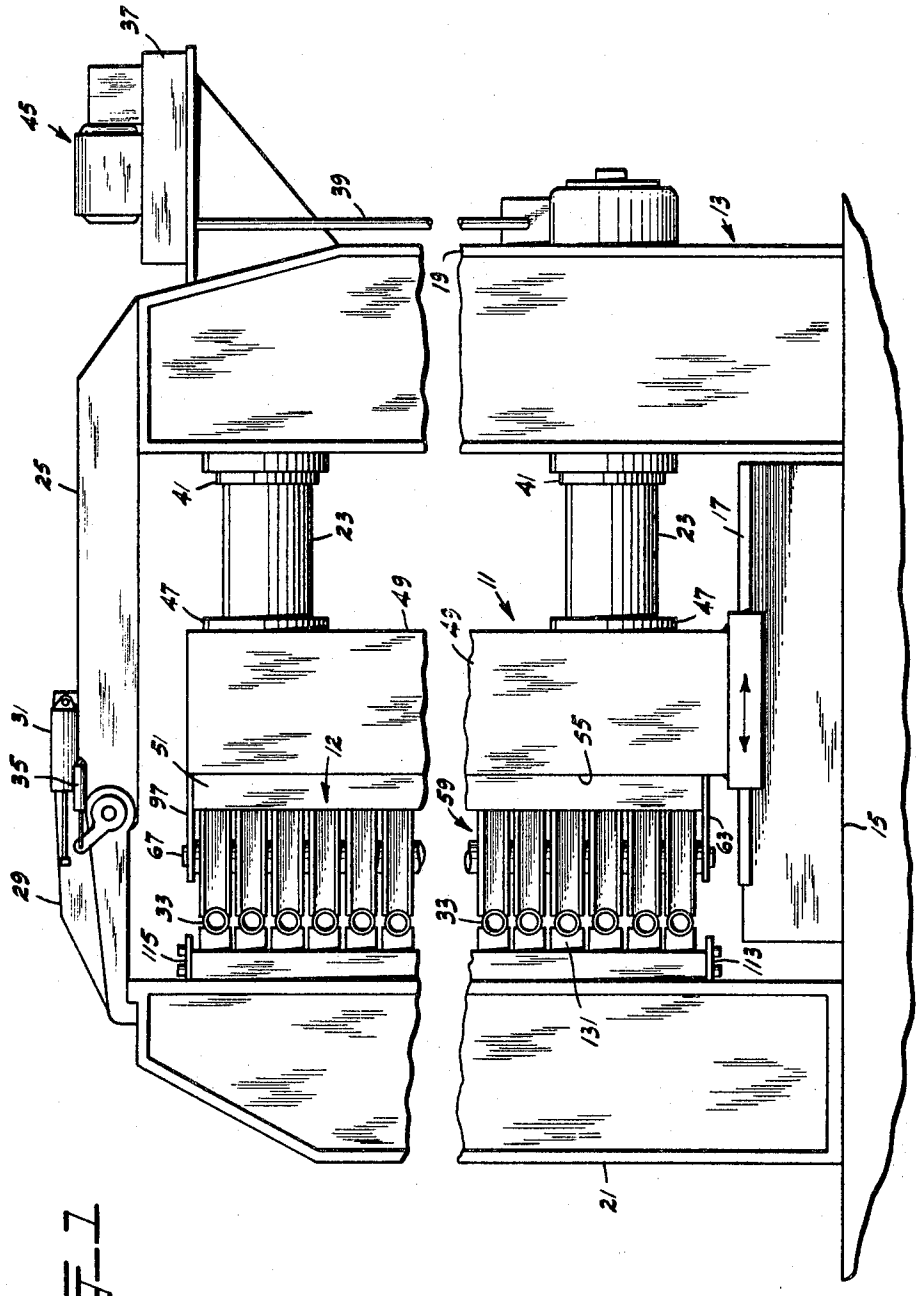


FIG. 1

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FIN-TUBE PANEL BENDING APPARATUS

Filed Dec. 10, 1965 6 Sheets-Sheet 2

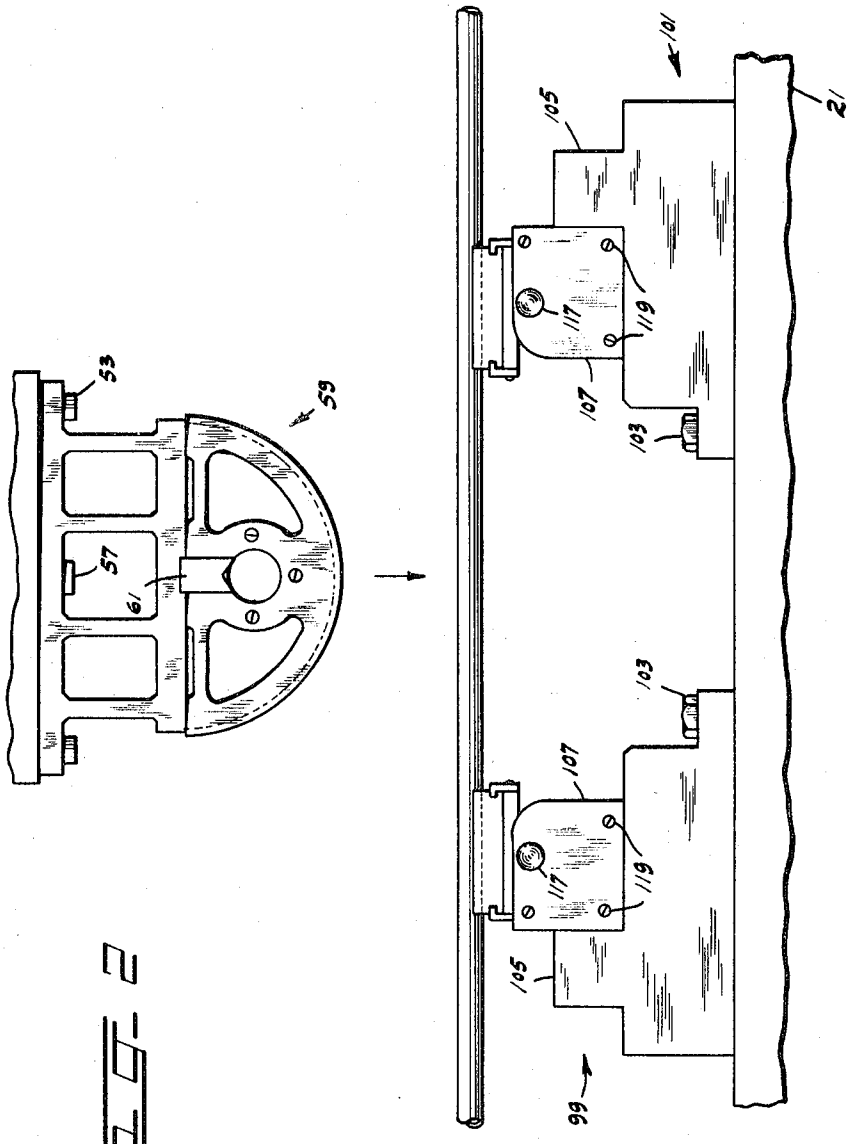


FIG. 2

July 2, 1968 L. E. CONKLIN 3,390,566

FIN-TUBE PANEL BENDING APPARATUS

Filed Dec. 10, 1965 6 Sheets-Sheet 3

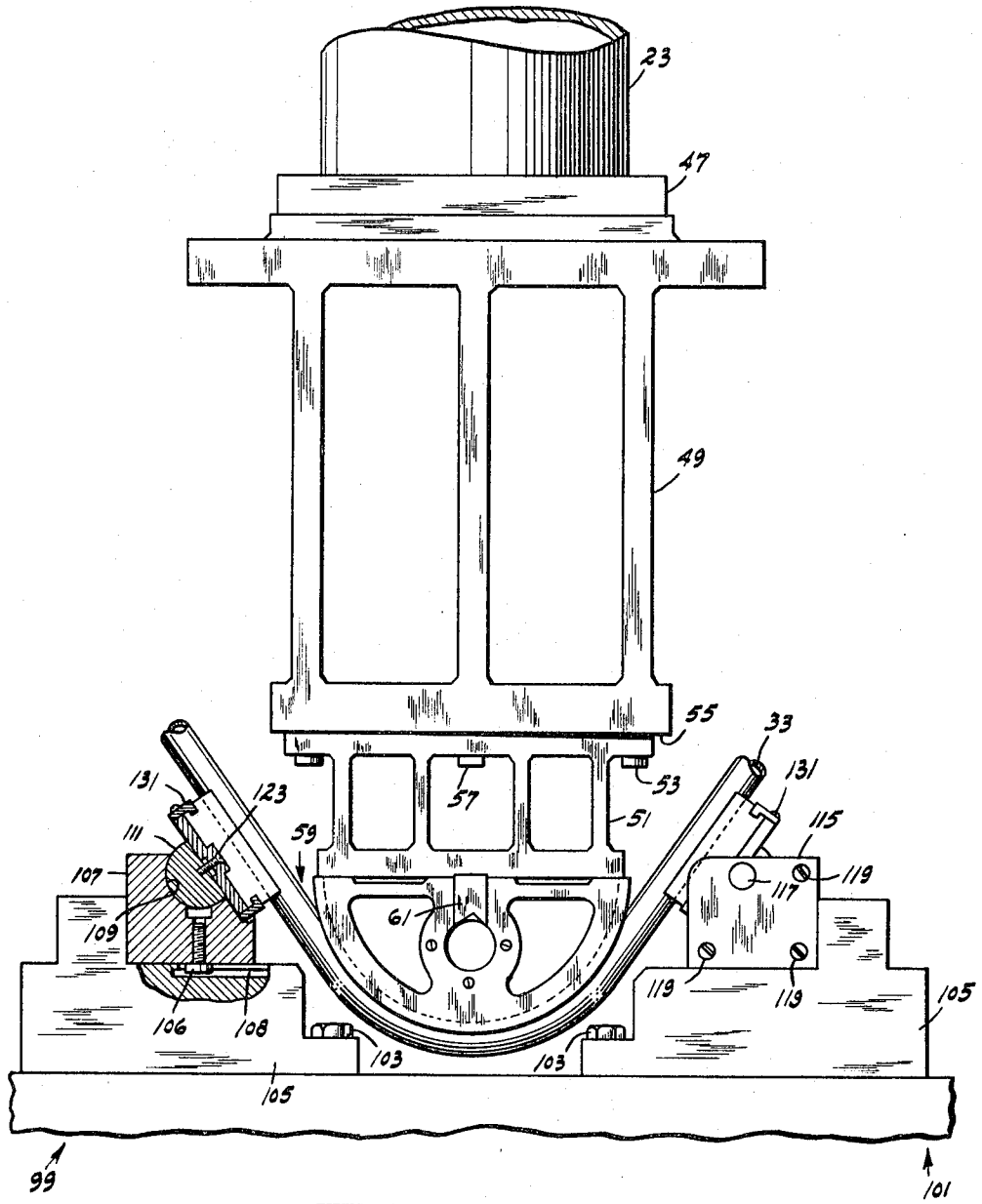


FIG. 3

FIN-TUBE PANEL BENDING APPARATUS

Filed Dec. 10, 1965 6 Sheets-Sheet 4

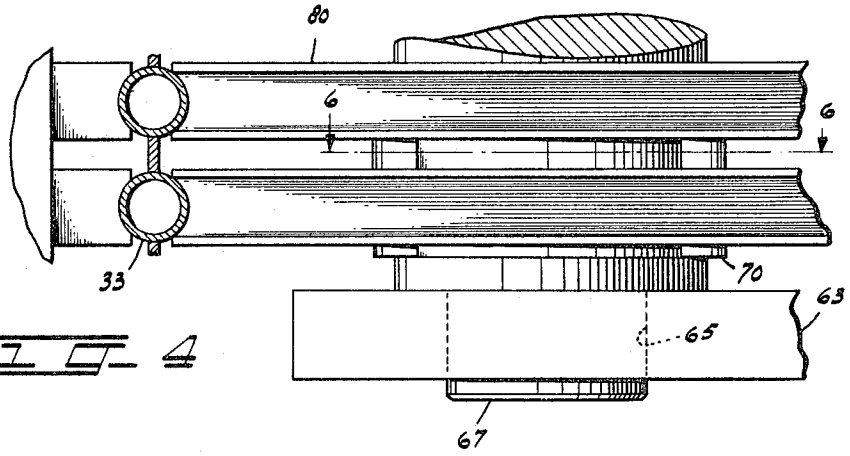


FIG 4

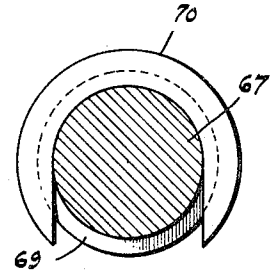


FIG 6

FIG 8

July 2, 1968 L. E. CONKLIN 3,390,566

FIN-TUBE PANEL BENDING APPARATUS

Filed Dec. 10, 1965 6 Sheets-Sheet 5

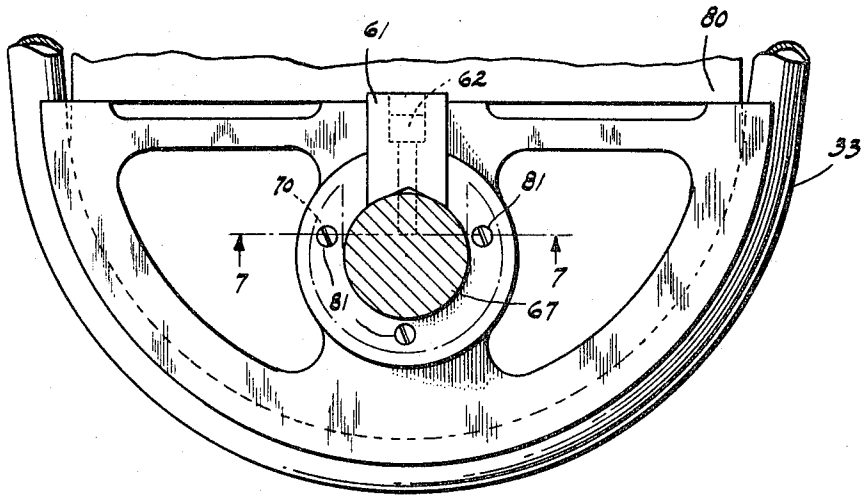


FIG. 5

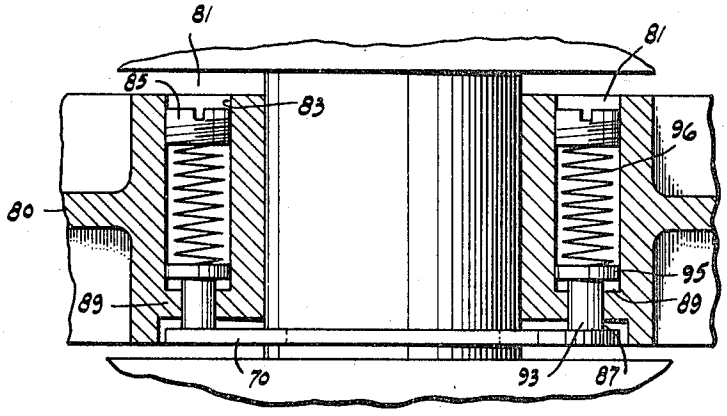


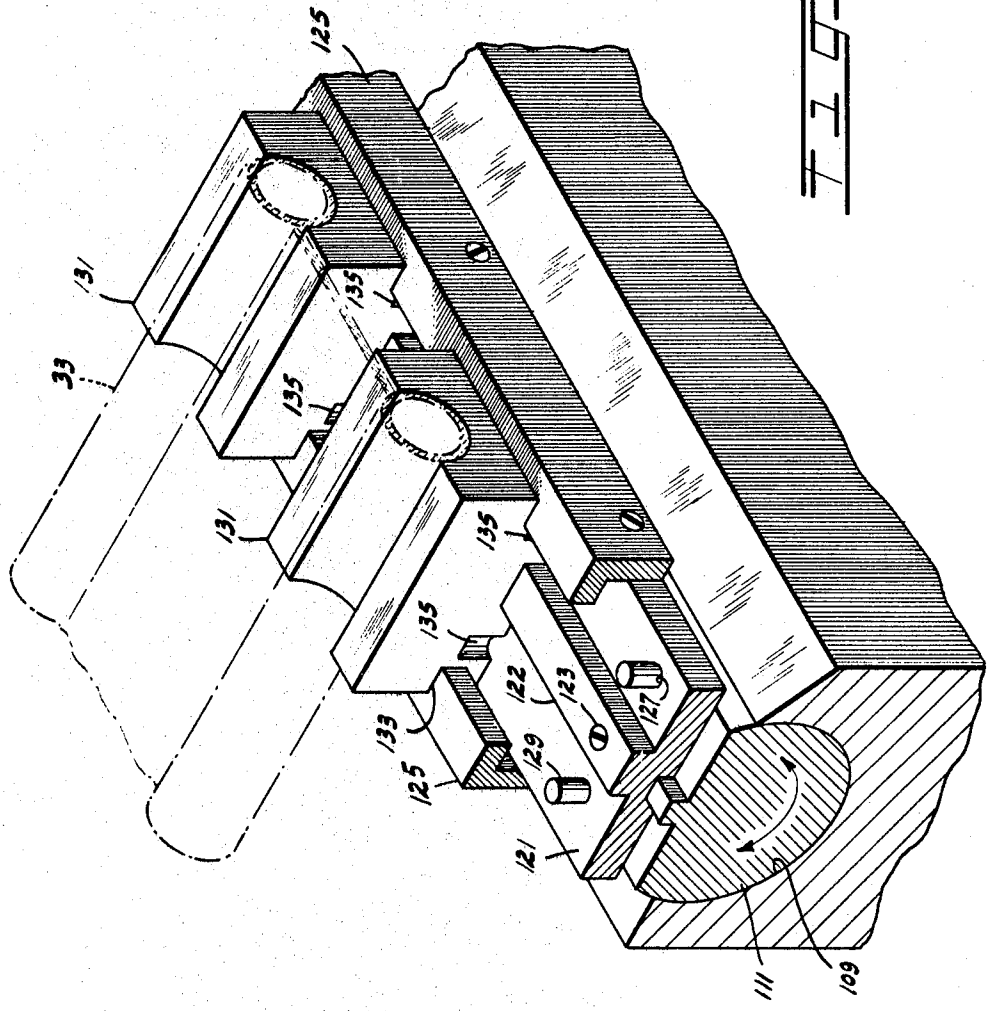
FIG. 7

July 2, 1968 L. E. CONKLIN 3,390,566

FIN-TUBE PANEL BENDING APPARATUS

Filed Dec. 10, 1965 6 Sheets-Sheet 6

FIG. 9



United States Patent Office 3,390,566 Patented July 2, 1968

3,390,566

FIN-TUBE PANEL BENDING APPARATUS

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7 Claims. (Cl. 72—389)

ABSTRACT OF THE DISCLOSURE

A fin-tube panel bending apparatus including vertically mounted male die segments and female die segments both vertically adjustable.

In modern steam generators, it is a common practice to form the walls of the generator into tube panels. Such tube panels can be fabricated in any number of ways. A common technique is to weld a fin between two adjoining tubes. The fin is placed between the tubes, either by seam welding a strip of metal to both tubes or by casting a fin which is totally integrated with both tubes. Of course, it is also possible to weld the two adjoining tubes together without the addition of a fin.

Prior to the use of fin-tube panels, each tube in a vapor generator was individually bent and subsequently assembled into a panel in the shop or placed in its proper location within the vapor generator at the erection site. Assembly of a panel after bending incurs a large amount of erection expense due to the configurations that must be welded by hand rather than utilizing automatic equipment. Since it is essential that such panels have a wide variety of configurations, it is most important that the panel be fabricated with the tubes flat and then the entire panel be bent in accordance with the particular design of the vapor generator.

In the past, presses were designed to bend such fin-tube panels. The original presses were constructed so that the panel was inserted in a horizontal plane. One difficulty which resulted with such an apparatus was the requirement of holding the moving ends of the panel as it is bent in overhead cranes. Also due to limitations on overhead space, the panel size which could be bent was limited. Subsequently, the idea was conceived of a bending apparatus in which the panels were inserted in a vertical plane within the fin-tube panel bender. The uses of cranes was minimized by placing the ends of the panel upon dollies which moved about the floor around the panel bender as the panel was bent into position. The panel bending apparatus previously utilized has provided only columns for pressing against the panel. In general, a single male column moved in relationship to a pair of female columns, forcing the desired bend in the tube panel. Although the desired bends can be achieved by this type of equipment, deformation of the fin-walled tubes within the fin-tube panel has remained as a problem.

Therefore, it is an object of this device to provide a panel-bending apparatus with die assemblies which eliminate tube deformation during the bending operation.

Another object is to provide a panel bending apparatus with die assemblies which allow for irregularities in spacing of the tubes in a tube panel.

Another object is to provide a panel bending apparatus with assemblies which can be readily converted depending upon the tube diameter.

In accordance with this invention, a vertical hydraulic press is utilized with a top latch to permit vertical insertion of the tube panel or movement of the crane through the press. A male die assembly is attached to a bulldozer in the form of individual segments of flat semicircular blocks having a rounded groove about the semicircular edge to engage the outside surface of a tube in a tube panel. Each segment is individually mounted in a vertically movable position with relationship to the other male die segments so as to automatically move in either direction vertically in accordance with the construction of the tube panel being bent. A female die assembly is similarly situated in spaced relationship to the male segments and although fixedly mounted with regard to the movement of the ram are pivotally mounted to rotate as the panel bends. The female die assemblies are also attached to move in at least one direction vertically to compensate for irregularities in the tube panel and like the male die segments have a horizontal rounded groove to engage the section of the surface of the tubes opposite to the section engaged by the male segments.

These and other objects and advantages which will be more apparent when considered in conjunction with the drawings in which:

FIGURE 1 is a side elevation of a panel bending apparatus partially broken away and incorporating the die assemblies in accordance with this invention.

FIGURE 2 is a top plan view of the die assemblies with only a small portion of the adjacent press shown and with the male die segments withdrawn from the tube panel to be bent.

FIGURE 3 is a top plan view similar to FIGURE 2 with the tube panel partially bent.

FIGURE 4 is an enlarged side elevation of a portion of the die assemblies shown in FIGURE 1.

FIGURE 5 is a top plan view of a male die segment with a portion of the bent tube panel in place.

FIGURE 6 is a sectional view along line 6—6 of FIGURE 4 of a U-shaped washer and a male die support shaft with the other components removed.

FIGURE 7 is a fragmentary cross-sectional view along line 7—7 of FIGURE 5.

FIGURE 8 is an exploded isometric view of a portion of the male die support shaft with a U-shaped washer.

FIGURE 9 is a fragmentary isometric view of a portion of the female die assembly.

Referring now to the drawings and more particularly to FIGURE 1, a panel bending apparatus **11** is shown which utilizes the die assemblies **12** in accordance with this invention. A frame **13** of the hydraulic bender **11** includes a base portion **15** with a track **17** on it and two fixed end portions, namely, a ram end **19** and a stop end **21**. Within the ram end **19** is a plurality of hydraulic rams **23**. The frame **13** also includes a top portion **25** which is rigidly connected to the ram end **19**. A pivotable latch **29** extends over from the top portion **25** to the stop end **21**. A hydraulic cylinder **31** is utilized to pivot the latch **29** to a vertical position to permit insertion of a tube panel **33** or to pass a crane through the panel bending apparatus. A smaller hydraulic cylinder **35** is used to pull the latch **29** tight against the stop end **21** in order to provide end restraint. As is necessary with such hydraulic equipment, an oil reservoir **37** is provided which is connected by tubes **39** to the individual cylinders **41** in which the rams or pistons **23** are slideably fitted. The pressure in the hydraulic reservoir is obtained by a motor and pump assembly **45**.

Attached to the rams **23** are platens **47** to which is secured a cross-head **49**. An extension block **51**, which may be in the form shown in FIGURES 2 and 3, is bolted by means of bolts **53** to the outside face **55** of the cross-head **49**. Dowels **57** are inserted through the back surface of the extension block **51** into the cross-head **49** to assure proper alignment. A male die assembly **59** is mounted on the extension block **51**. A V-block **61** in the form of a metal bar with a 60-degree groove in its outer surface is bolted vertically by bolts **62** along the vertical center line of the extension block **51**. A male bottom shaft support plate **63** as shown in FIGURES 1 and 4 is bolted to the lower end of the extension block **51**. An opening **65** in the male bottom shaft support plate **63** receives the lower end of a male die support shaft **67** which is vertically oriented and in contact with the groove in the V-block **61**. The male die support shaft **67** is a long circular steel bar having grooves **69** about its periphery into which are inserted U-shaped washers **70**.

In forming the male die assembly, a support washer **70** is placed in the bottom groove of the male die support shaft **67**. A male die segment **80** is then placed over the top end of the male die support shaft and V-block **61** and slid vertically downward until it rests upon the lowest washer **70**. As best seen in FIGURES 5 and 7, three openings **81** are located in each male die segment **80** about the periphery of the male die support shaft **67**. The upper ends **83** of the openings **81** are threaded to hold a plug **85**. The lower ends of the openings **81** have a reduced diameter to form a ridge **89** for a plunger **93**. The lower ends of the openings **81** are small enough for lower ends **87** of the plungers **93** to extend outward but not sufficiently large to permit passage of the larger upper ends **95** of the plungers **93** which are stopped by the ridges **89**. Between the plug **85** and the plunger **93** a coil spring **96** is located which is under compression and forces the head of the plunger against the ridge **89**. When one of the segments **80** rests upon one of the U-shaped washers **70** it contacts it only at the bottom end of the plunger and therefore floats upon the springs. Another washer **70** is then placed in the next groove **69** and another male die segment **80** is similarly slid down in contact with that support washer **81**. Each segment **80** is located on the male die support shaft **67** one above the other with a washer **70** beneath it. A top shaft support **97** is then bolted to the extension block **51** and holds the upper end of the male die support shaft **67** in the same manner as the lower shaft support **63** holds the lower end. As best seen in FIGURES 4 and 7, each individual segment **80** is free to move up and down on the plungers **93** in accordance with the unavoidable minor irregularities in the panel **33**. In addition, each male die segment **80** engages a major portion of the partial surface of the tube but has clearance between the edges of the segments **80** and the fins adjacent such edges thereby distributing the bending pressure across the face of the tubes in the panel and avoiding deformation of the individual tubes. Since tube sizes vary in fin-tube panels the individual segments are made in varying sizes to accommodate the tube size used in any particular panel and can be readily installed as needed. For this reason the grooves **69** in the male die support shaft **67** are not evenly spaced so as to permit equally spacing segments **80** of varying sizes by utilizing selected grooves **69** for each size of segment **80**. Also to assist in spacing male die segments **80** of varying sizes, specific U-shaped washers **70** can have a raised section attached to their face.

Referring now to the female die assembly **97** as best seen in FIGURES 2, 3 and 9, only one side of the pair of members will be described as they are mirror images of one another although left **99** and right **101** in operation. Bolted to the face of the stop end **21** by bolts **103** are two adaptor blocks **105** which are symmetically located on both side of the male die assembly **59**. Secured to the adaptor blocks **105** are back-up blocks **107** which

have a cylindrical concave groove **109** vertically located therein. The back-up blocks **107** are secured by means of bolts **106** whose heads are fitted into a slide channel **108**. Fitted within the cylindrical concave groove **109** are female pivot shafts **111** which are held in place by means of a bottom bearing block **113** and a top bearing block **115** each of which has an opening **117** therein for mounting of the ends of the female pivot shafts **111**. Both bottom and top bearing blocks **113**, **115** are fastened by means of bolts **119** to the adaptor blocks **105**. Female die support bars **121** are bolted preferably by a series of bolts **123** to the female pivot shafts **111**. The female die support bars **121** are in the form of flat vertically-oriented plates with a longitudinal raised portion **122**. A pair of female die clamps **125** are bolted to both vertical edges of each female die support bar **121** to form a groove at both edges of the female die support bars **121**. Dowel holes **127** are spaced at various locations along the female die support bar **121** into which metal dowels **129** are slip fitted. At the bottom end of the female die support bars **121** a pair of dowels **129** are located in a common horizontal plane. A female die segment **131** is slipped down with end notches **133** to fit the female die clamps **125** until dowel grooves **135** located in the lower edge of the female die segments **121** rest upon a pair of dowels **129**. Another pair of dowels **129** are then placed in the openings provided directly above the already inserted female die segment **131** and another female die segment **131** is slipped down in contact with those dowels **129**. When all the segments **131** have been placed in position, the top bearing block **115** is bolted down as previously discussed. In this way, although the female segments cannot move downward beyond their respective supporting dowels, they can move vertically upward to the pair of vertically supporting dowels above them permitting movement to compensate for irregularities. In addition, as best seen in FIGURE 3, as the male segment moves inward between the female die assembly, the female die assembly **97** pivots to compensate for the angular bend of the panel **33** thereby constantly remaining in contact with the surface of the panel **33**.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A fin-tube panel bending apparatus comprising:

a male die assembly including male die segments mounted one above the other, said male die assembly including means to adjust the vertical position of each male die segment in relation to the male die segment beneath it and to the male die segment above it;

a pair of female die assemblies mounted symmetrically in a spaced relationship to said male die assembly, said pair of femle die assemblies each including female die segments one above the other, said female die assemblies including means to adjust the vertical position of each female die segment and further including means to rotate the female die segments about a vertical axis; and

means for causing relative horizontal movement between said male die assembly and said pair of female die assemblies.

2. A fin-tube panel bending apparatus comprising:

male die segments including flat semicircularly-shaped blocks having a rounded groove about the semicircular edge;

means for mounting said male die segments one vertically above the other with each male die segment free to move vertically in relation to the male die

segment below it and the male die segment above it, said rounded groove about the semicircular edge lying in a horizontal plane;

female die segments including rectangular blocks having a rounded groove along the length of one surface;

means for mounting said female die segments in two symmetrical locations in spaced relationship to said male die segments, said female die segments in each location being positioned one vertically above the other and with each female die segment free to move vertically, said means for mounting including means for pivoting the female die segments about a vertical axis at each of the two symmetrical locations, said rounded groove along the length of one surface of the female die segments lying in a horizontal plane and generally directed toward said male die segments; and

means for causing relative horizontal movement between said male die segments and said female die segments.

3. A fin-tube panel bending apparatus according to claim 2 wherein said means for mounting said male die segments includes a male die support shaft in the form of a long round bar having a multiplicity of grooves about its periphery spaced along its length and male support washers having a U-shape fitted into one of said grooves along said male die support shaft, said male die segments including spring-loaded plungers extending from the lower surfaces of said male die segments and resting against said male support washers.

4. A fin-tube panel bending apparatus according to claim 2 wherein said means for mounting said female die segments includes a pair of pivotably mounted female die support bars, said pivotably mounted female die support bars including vertical members with holes located along their length and a series of dowels fitted into said series of holes in horizontal pairs spaced along the length of each of said pair of female die support bars.

5. A fin-tube panel bending apparatus comprising:

a male die support shaft including a vertically mounted long round bar with a multiplicity of grooves about its periphery and spaced along its length;

male support washers having a U-shape fitted into at least a portion of said grooves along said male die support shaft;

male die segments including flat semicircular blocks with an opening therein adapted to fit about said male die support shaft and having a rounded groove about the semicircular edge, said male die segments each having spring-loaded plungers extending from its lower surface, each male die segment being mounted over one of said male support washers with the spring-loaded plungers resting on the male support washer directly beneath it, said rounded groove about the semicircular edge lying in a horizontal plane;

a pair of female die assemblies mounted symmetrically in spaced relationship to said male die segments, said female die assemblies each including female die segments one above the other, said female die assemblies including means to adjust the vertical position of each female die segment and to rotate the female die segments about a vertical axis; and

means for causing relative horizontal movement between said male die segments and said female die segments.

6. A fin-tube panel bending apparatus comprising:

a male die assembly including male die segments mounted one above the other, said male die assembly including means to adjust the vertical position of each male die segment in relation to the male die segment beneath it and to the male die segment above it;

a female support means rigidly mounted in spaced relationship with the male die assembly;

a pair of female pivot shafts each including a long round bar flattened on one side along its length pivotably mounted in a vertical position on said female support means;

a pair of female die support bars including long flat plates secured to said pair of female pivot shafts, said pair of female die support bars each having a series of holes located along its length;

a series of dowels mounted in said series of holes in horizontal pairs spaced along the length of said pair of female die support bars;

female die segments including rectangular blocks each having a rounded groove along the length of one surface and each being mounted on one of said horizontal pairs of dowels, said dowels being spaced vertically apart at a slightly larger distance than the vertical dimension of said female die segments;

clip means for retaining said female die segments against said female die support bars, said clip means being adapted to permit vertical movement of each female die segment; and

means for causing relative horizontal movement between said male die segments and said female die segments.

7. A fin-tube panel bending apparatus comprising:

a horizontally movable ram;

a ram extension assembly means secured to said horizontally movable ram, said ram extension assembly means having an inner surface connected to said ram and an outer surface opposite from said inner surface;

a male die support shaft in the form of a long round bar having a multiplicity of grooves about its periphery spaced along its length;

means for vertically mounting said male die support shaft on said outer surface of said ram extension assembly means;

male support washers having a U-shape fitted into at least a portion of said grooves along said male die support shaft;

male die segments in the form of flat semicircular blocks with an opening therein adapted to fit about said male die support shaft and having a rounded groove about the semicircular edge, said male die segments having spring-loaded plungers extending from its lower flat surface, each male die segment being mounted over one of said male support washers with the spring-loaded plungers resting on the male support washer directly beneath it whereby each male die segment can be moved up and down on the spring-loaded plunger;

a pair of female support means rigidly mounted symmetrically in a horizontal plane opposite said outer surface of said ram extension assembly means;

a pair of female pivot shafts in the form of a long round bar flattened on one side along its length pivotably mounted along a vertical axis on said pair of female support means;

a pair of female die support bars in the form of long members bolted along said pair of female pivot shafts, said pair of female die support bars each having a series of horizontal pairs of holes located along its length;

a series of dowels fitted into said series of horizontal pairs of holes located along the length of said pair of female die support bars;

female die segments including rectangular blocks having a rounded groove along the length of one surface, each of said female die segments being mounted on one of said horizontal pairs of said dowels, said dowels being spaced vertically apart a slightly larger distance than the vertical dimension of said female die segments whereby said female die segments can

lift up to the next higher pair of dowels from the pair of dowels directly beneath it; and

clip means attached to the side edges of said female die support bars for retaining said female die segments against said female die support bars.

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