Sept. 21, 1971 R. C. WHITMAN 3,606,788

SHORT-RADIUS SQUEEZE BENDING APPARATUS

Filed Oct. 14, 1969 2 Sheets-Sheet 1

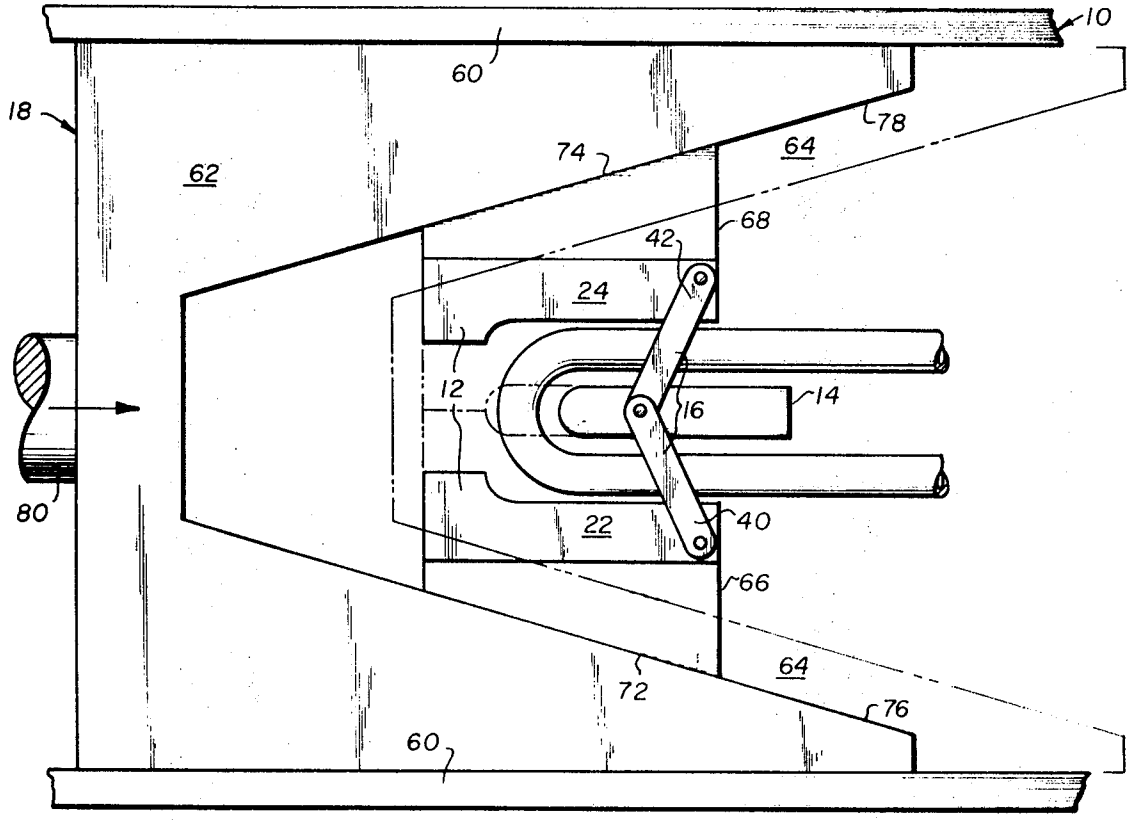


FIG. 1

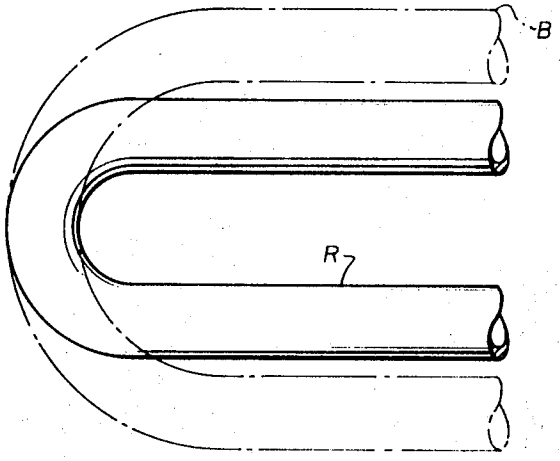


FIG. 4

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SHORT-RADIUS SQUEEZE BENDING APPARATUS

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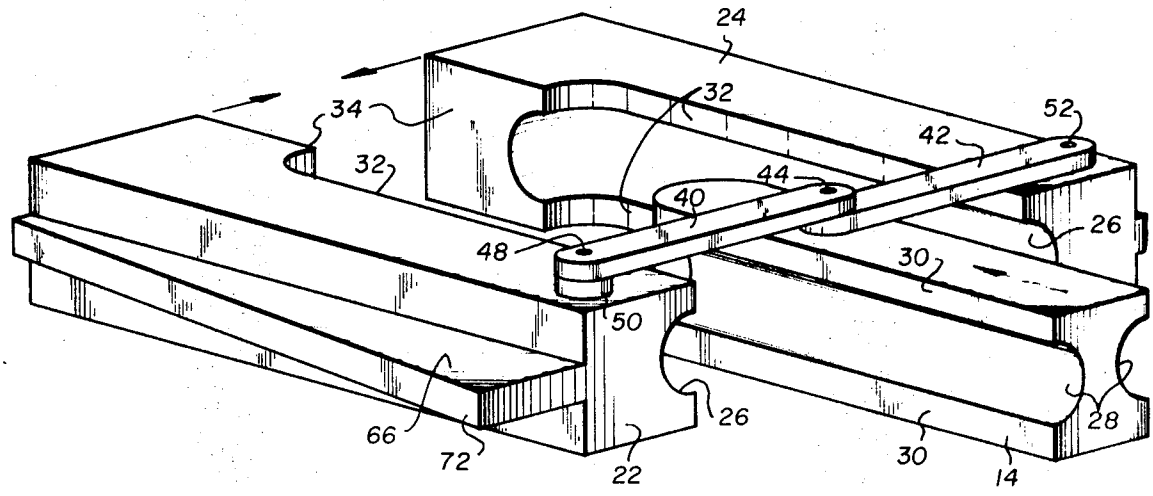


FIG. 2

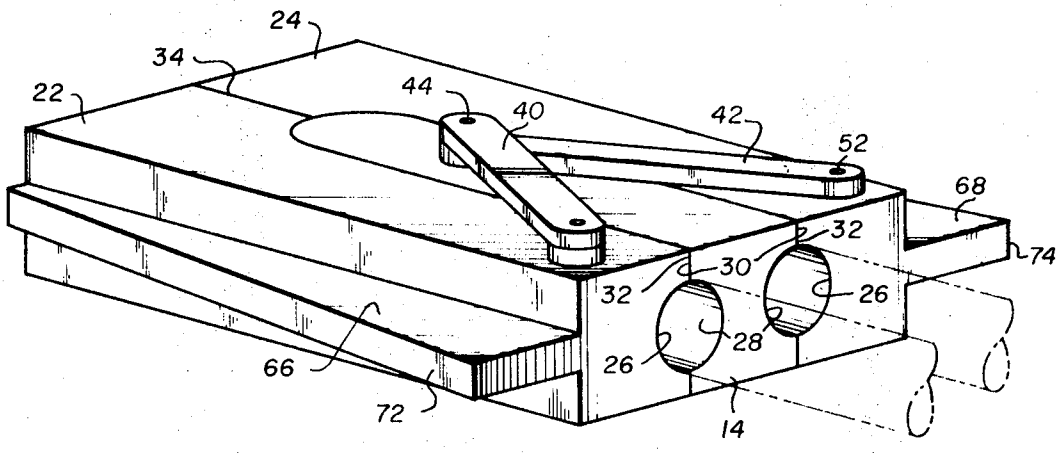


FIG. 3

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SHORT-RADIUS SQUEEZE BENDING APPARATUS

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U.S. Cl. 72—389 3 Claims

ABSTRACT OF THE DISCLOSURE

A squeeze bending apparatus in which a tube blank, previously fabricated with a relatively wide bend, is formed with a short radius tube bend. An inner die is operatively connected between a pair of outer dies for conjointly bringing the dies together at a uniform rate of movement such that short radius bends can be uniformly fabricated.

BACKGROUND OF THE INVENTION

In the construction of relatively large vapor generators, there is a distinct advantage in placing a relatively large number of convection heating tubes in a given space. By tightly packing the convection tubes, it is possible to achieve higher heat transfer rates, since the enclosure surrounding the tubes become smaller, thereby requiring less material. Thus, in order to place the largest possible number of tubes in a relatively small space, it is necessary to bend relatively heavy wall tubing into short radius bends. It has been the practice to form short radius bends by heating the tubes immediately prior to performing the bending operation. This is usually accomplished by placing an induction heating coil around a straight tube and then forming the short radius bend on the hot tube. The formation of short radius bends on heated tubes by this method has become increasingly difficult with the use of more complex coil designs which have come into being with new designs of vapor generators. Accordingly, the present invention provides a squeeze bending apparatus for forming short radius bends in relatively heavy tubing in order to meet present day demands in the manufacture of large vapor generators. Thus, it is possible to fabricate tube panels which have complex configurations from a single long length of tubing and form the required radius bends progressively as required during the formation of a given single tube panel. In this manner, a complex tube panel can be formed in a series of operations, thereby eliminating the need of forming a number of smaller tube panel sections which ultimately had to be joined together into the single tube panel.

SUMMARY OF THE INVENTION

In accordance with an illustrative embodiment, demonstrating objects and features of the present invention there is provided a squeeze bending apparatus for forming a short radius tube bend from a tube blank which has been previously fabricated with a relatively wide bend. A pair of outer dies are mounted for movement between an open position, with the outer dies spaced apart from each other and a closed position with the outer dies abutting each other. The outer dies are formed with cavities which conform to the shape of the outer portion of the short radius bend when the outer dies are in the closed position. An inner die is mounted for movement with the outer dies between the open position, with the inner die positioned between and spaced apart from the outer dies, and the closed position, with the inner die abutting the outer dies. The inner dies are formed with a cavity conforming to the inner portion of the short radius bend, when the inner die and outer dies are in the closed position. Operatively connected between the inner die and the outer dies are means for conjointly bringing the dies together at a uniform rate of movement such that short radius bends can be uniformly fabricated.

In accordance with the method aspects of the present invention, a short radius tube bend from a tube blank which has previously been fabricated with a relatively wide bend is positioned between a pair of outer dies and an inner die which are formed with cavities conforming to the outer configuration if the short radius tube bend. The outer dies and inner die are then conjointly brought together at a uniform rate of movement from an open position with the die spaced apart from each other to a close position with the dies abutting each other, such that short radius bends can be fabricated.

BRIEF DESCRIPTION OF THE DRAWINGS

The above brief description as well as further objects, features, and advantages of the present invention will be more fully appreciated by referring to the following description of presently preferred but nonetheless illustrative embodiments in accordance with the present invention, when taken in connection with the accompanying drawings wherein:

FIG. 1 is a plan view of a short radius squeeze bending apparatus in accordance with the present invention, with the dies shown in the open position;

FIG. 2 is an elevational view of the dies removed from the bending apparatus and shown in an open position;

FIG. 3 is an elevational view similar to FIG. 2 but with the dies shown in a closed position; and

FIG. 4 is a plan view of a tube formed with a short radius tube bend, shown in solid lines, and with the relatively wide bend, previously formed tube blank shown by the broken lines.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now specifically to the drawings, there is shown a short radius squeeze bending apparatus embodying features of the present invention and generally designated by the reference numeral **10**. The short radius tube bend formed in accordance with the present invention is designated by the letter R in FIG. 5, where there is also shown a tube blank designated B, which has previously been fabricated with a relatively wide bend. It should be understood that after the wide bend has been formed, the tube blank B is heated, preferably by means of induction heating coils, which are well known in the art and have not been shown in the drawings.

The squeeze bending apparatus **10** includes a pair of outer dies **12** mounted for movement from an open position shown in FIG. 2 to a closed position shown in FIG. 3. An inner die **14** is mounted on the outer dies **12** for movement between the open position and closed position. For conjointly bringing dies **12** and **14** together, a pair of links **16** are connected between inner die **14** and outer dies **12**, and a mounting yoke **18** is provided for slideably receiving outer dies **12**. By referring to FIG. 2 it can be seen that the outer dies **12** include a left die member **22** and a right die member **24**, which are substantially identical in configuration. The outer dies **22** and **24** are integrally formed with die cavities **26** which conform to the outer portion of the exterior configuration of the short radius tube R. The inner die **14** is formed with a continuous die cavity **28** which conforms to the inner portion of the exterior configuration of short radius tube R. Thus, when the outer dies **12** are in the open position of FIG. 2, with dies **22** and **24** spaced apart from each other, it is possible to insert the tube blank B in outer die cavities **26**. The inner die cavity **28** is bordered by a pair of raised

lands **30** which coextensively mate with pairs of raised lands **32** which border the opposite sides of outer cavities **26** when in the closed position of FIG. 4. The abutting surfaces of outer dies **12** also include side faces **34** which coextensively meet in the closed position of FIG. 4, such that the outer grooves **26** of dies **22** and **24** form a continuous groove in conformity with the outer configuration of short radius bend R.

For operatively connecting the outer dies **12** to inner die **14**, the linkage **16** includes a left link **40** and a right link **42** which are mounted on a common pivot **44** that is fixed to inner die **14**. The left link **40** is pivoted on the left die member **22** by means of a pivot **48** which is fixed to die member **22**. A spacer disc **50** is journaled on pivot **48** between the top portion of die member **22** and link **40**, to maintain link **40** in a level position. The right link **42** is pivoted on the right die member **24** by means of a pivot **52** which is fixed to die member **24**.

The mounting yoke **18** includes a pair of stationary side braces **60** between which there are movably mounted a central housing **62** which is formed with a key-way channel **64**. The outer dies **12** are slideably received in key-way channel **64** by means of side arms **66** and **68** which are formed on the side portion of outer die members **22** and **24** respectively. The side arms **66** and **68** are integrally formed on die members **22** and **24** respectively, with inclined edge surfaces **72** and **74**. As best seen in FIG. 1, the key-way channel **64** is formed with inclined edge surfaces **76** and **78** which have the same angle as the surfaces **72** and **74**. Thus, by respectively forming edge surfaces **72** and **76** and edge surfaces **74** and **78** with the same angle, sliding contact is achieved in key-way channel **64**.

For bringing the outer dies **12** and inner die **14** together, there is provided a press cylinder **80**, and stop means are located at inner die **14**. The stroke of the cylinder **80** results in central housing **62** sliding forward in the side braces **60** such that the outer dies **12** and inner die **14** are brought together at a uniform rate of movement.

A latitude of modification, change and substitution is intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.

I claim:

1. A squeeze bending apparatus for forming a short-radius tube bend from a hot tube blank which has been previously fabricated with a relatively wide bend, comprising a pair of outer dies mounted for movement between an open position, with said outer dies spaced apart from each other and, a closed position with said outer dies abutting each other, said outer dies formed with cavities which conform to the shape of the outer portion of said short-radius bend when said outer dies are in said closed position, an inner die mounted for movement with said outer dies between said open position, with said inner die positioned between and spaced apart from said outer dies, and said closed position with said inner die abutting said outer dies, said inner dies formed with a cavity conforming to the inner portion of said short-radius bend when said inner die and outer dies are in said closed position, and means operatively connected between said inner die and outer dies for conjointly bringing said dies together at a uniform rate of movement such that short-radius bends can be uniformly fabricated.

2. Apparatus for forming a short-radius squeeze bend according to claim **1** in which said means for conjointly bringing the dies together include a pair of links with the outer end of each of said links movably mounted on a pivot on each of said outer dies and the inner end of each of said links movably mounted together on a pivot on said inner die, and an outer yoke formed with a key-way channel for slideably receiving said outer dies and uniformly constraining the conjoint movement of said inner and outer dies from said open position to said closed position.

3. A method of forming a short-radius tube bend from a tube blank which has been previously fabricated with a relatively wide bend and heated comprising the steps of:

positioning said tube blank between a pair of outer dies and an inner die which are formed with cavities conforming to the outer configuration of said short-radius tube bend; and

conjointly bringing said outer dies and inner die together at a uniform rate of movement from an open position with said dies spaced apart from each other to a closed position with said dies abutting each other such that short-radius bends can be uniformly fabricated.

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72—399, 452