May 20, 1958
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2,835,306
METHOD AND APPARATUS FOR PRODUCING SEAMLESS SHARP BENDS
IN WAVE GUIDE TUBING TO REPLACE MITERED SOLDERED BENDS
Filed Aug. 20, 1952

2 Sheets—Sheet 1

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METHOD AND APPARATUS FOR PRODUCING SEAMLESS SHARP BENDS IN WAVE GUIDE TUBING TO REPLACE METERED SOLDERED BENDS

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Application August 20, 1952, Serial No. 365,325

8 Claims. (Cl. 153—21)

This invention pertains to methods of and apparatus for bending wave guide tubing and more particularly to methods of and apparatus for producing seamless sharp bends in wave guide tubing.

In the bending of wave guide tubing it is essential that the internal dimensions of the finished wave guides be uniform throughout and that both the internal and external surfaces be smooth. In the past, sharp bends in wave guide tubing have been produced by mitring three separate sections of tubing at the desired angles and joining them by brazing the joints. This is a costly procedure and unsatisfactory because a discontinuity is formed in the wall of the wave guide where the sections are brazed which affects the transmission qualities of the wave guide transmission line and reduces the transmission efficiency of the line.

It is an object of the present invention to economically bend wave guide tubing from a single integral piece so as to have no discontinuities therein.

Another object of this invention is to provide a tube bending apparatus having improved dies and mandrels so that the wave guides are formed with a minimum distortion of the material of the tubing and with few imperfections therein.

In order to attain these and other objectives, and in accordance with the general features of the invention, one embodiment provides an apparatus having three bending operations, each bending operation performing one step in the formation of the finished wave guides.

The first operation involves a pair of dies having complementary curved faces for receiving a partially bent wave guide tubing, two side engaging mandrels curved complementary to the faces of the dies and means for moving the dies into engagement with the external walls of the bending mandrels into contact with the internal walls of the wave guide tubing. The second bending operation involves dies having complementary angular sinks for supporting the external walls of the wave guide tubing, side engaging mandrels having pivoted cam blocks therefor for supporting the internal walls of the wave guide tube and means for moving the dies into engagement with the side engaging mandrels into the interior of the wave guide tube thereby causing the pivoted blocks to cam into engagement with the internal walls of the tubing. The third operation produces a transverse corrugation in the formed wave guide and comprises means for supporting the said guide, the said supporting means having a transverse groove therein, and a moveable die whose face is shaped complementary to the transverse groove in said supporting means.

Other novel features and advantages of the present invention will become apparent in the following description when considered in conjunction with the accompanying drawings, wherein:

Fig. 1 is a plan view of a bending apparatus performing the first step of the bending operation;

Fig. 2 is a plan view of a preferred embodiment of such apparatus for performing the second step in the bending operation and depicts the machine in its retracted position prior to the bending operation;

Fig. 3 is a plan view of the apparatus shown in Fig. 2 after the bending operation has been completed;

Fig. 4 is a front elevational view of the apparatus used to complete the bending operation with the wave guide tubing shown therein in cross section; and

Fig. 5 is an enlarged perspective view of a completed wave guide bent by the apparatus disclosed in Figs. 1-4, inclusive; and

Fig. 6 is a perspective view of a section of preformed wave guide tubing prior to bending in accordance with the teaching of the present invention.

Referring now to the drawings, and in particular to Fig. 6, a piece of partially bent wave guide tubing 13 is shown ready for the first bending operation in accordance with the present invention.

Attention is next directed to Fig. 1 in which a bending apparatus 10 is shown after the completion of a first step in the bending of a wave guide. A base 11 of the bending apparatus 10 has secured thereon a stationary die 12 which has formed therein an angular sink 14 for receiving a partially bent wave guide tubing 15 shown in cross section. A movable die 16 is fastened to an operating head 17 and is moved thereby into engagement with the wave guide tubing 15. At the same time the left ends of two mandrels 18 are engaged by faces 19 of the moving operating head 17 thereby forcing the mandrels into contact with the internal walls of the wave guide tubing 15. Two guide blocks 21 are secured to the base 11 and guide the movable die 16 therewith and into contact with the left side external wall of the wave guide tubing 15. The guide blocks 21 also cooperate with angularly positioned faces 22 of the stationary die 12 to guide the mandrels 18 into engagement with the internal walls of the wave guide tubing 15.

Attention is next directed to Fig. 2 wherein bending apparatus 29 is shown in an open or retracted position prior to a bending operation. A base 26 of the machine 29 has mounted thereon a concave die consisting of stationary die sections 31 and a movable die section 32. A pin 28 is attached to the base 30 and guides the movable die section 32 into engagement with the right side external wall of the wave guide tubing 15 when the movable die section 32 is actuated by a piston 34. At the same time that the convex movable die 37 is actuated, faces 39 of the operating head 35 engage two angularly positioned compound mandrels 40 and force them against the internal walls of the wave guide tubing 15. Each of the mandrels 40 includes a retaining sleeve 41 that is secured to the base 30 and which follows reciprocable arms 42 and operating member 43. The reciprocable arms 42 and the operating members 43 are in longitudinal sliding contact with each other and are held in this position by the retaining sleeves 41. Concave arcuate portions of the reciprocable arms 42 are positioned within the wave guide tubing 15 and arcuate cam blocks 44 nest therein. When the operating head 35 moves toward the right, the faces 39 thereof contact the operating members 43 of the mandrels 40 and moves...
them longitudinally in the retaining sleeves 41 until the beveled faces 49 of the operating members 43 contact the cam blocks 44. The cam blocks 44 are then pivoted into engagement with the left side internal wall of the wave guide to support it during bending. The operating head 35 also engages the reciprocable arms 42 and moves them longitudinally into contact with the right side internal wall of the wave guide 15 to support it during bending.

Referring now to Fig. 4, a supporting die 45 is attached to a base 46 and holds the partially formed wave guide 15 on its upper surface which has therein a transverse groove 48. A corrugating die 50 is attached to a piston 51 and is movable into contact with the partially formed wave guide 15. A cylindrical member 53 of the corrugating die 50 cooperates with the transverse groove 48 in the supporting die 45 to produce a corrugation 55 (Fig. 5) in the wave guide 15 when the piston 51 is actuated. Circular portions 54 of the corrugating die 50 engage and support the side walls of the wave guide 15 during the corrugating operation.

Although the invention has been described with reference to a particular embodiment, it is to be understood that various modifications may be made without departing from the spirit and scope of the invention. What is claimed is:

1. An apparatus for bending V-shaped wave guide tubes comprising a base, reciprocable arms slidably mounted on said base, means for moving said arms into engagement with the external walls of a wave guide tube, reciprocable arms extending into said wave guide tube, reciprocable arms having therein arcuate recesses located adjacent the portions of the wave guide tube which are engaged by one of said reciprocable dies, cam means pivotally nested in said arcuate recesses, means actuated by said die moving means for forcing said reciprocable arms into contact with the internal walls of said wave guide tube, and operating means actuated by said die moving means for pivoting said cam means into engagement with an internal wall of the wave guide tube that is opposite the wall engaged by said reciprocable arms.

2. A side engaging mandrel for supporting a section of wave guide tubing during a bending operation, said mandrel comprising a retaining sleeve, a reciprocable arm slidably mounted therein and having a curved end for contacting an internal wall of the section of wave guide tubing being bent, said reciprocable arm having a concave arcuate portion adjacent said curved end, a cam block pivotally nested in said concave arcuate portion, said cam block engaging with a tub wall subjected to bending, an operating member enclosed in said retaining sleeve and in longitudinal sliding contact with said reciprocable arm, said operating member having a beveled face for engaging said cam block and pivoting it into engagement with an internal wall of the section of wave guide tubing during bending.

3. An apparatus for bending a section of wave guide tubing comprising a base, a first movable die section slidably mounted thereon, stationary die sections cooperating with said first movable die section to support the convex side of the section of wave guide tubing being bent, an operating head, a second movable die section attached thereto, and a plurality of mandrels movable into supporting contact with the internal walls of said section of wave guide tubing by said operating head, said mandrels each comprising a reciprocable arm adapted to be contacted by said operating head, an arcuate cam block pivotally nested in said reciprocable arm, an operating member in longitudinal sliding contact with the arcuate cam block to pivot it into contact with the internal walls of the wave guide tubing at a position opposite the second movable die section when said operating member is contacted by said operating head, and a retaining sleeve secured to said base to guide said reciprocable arm and said operating member into the wave guide and to retain said reciprocable arm and said operating member in longitudinal sliding contact.

4. An apparatus for bending wave guide tubes comprising a base; a concave die mounted thereon, said concave die including two stationary die sections and a movable die section therebetween, means for moving said first movable die section into contact with a wave guide tube to be bent; a plurality of mandrels for supporting the internal walls of the wave guide tube during bending, each mandrel including an operating member, a reciprocable arm in sliding contact with said operating member and having a concave arcuate portion and a cam block nest in said concave arcuate portion and adapted to be cammed into engagement with the internal walls of the wave guide tube by said operating member; an operating head including a second movable die section attached thereto for cooperating with said concave die to bend the wave guide tube, and said contact faces formed integral with the operating head to contact said operating members and said reciprocable arms to force the reciprocable arms into engagement with the internal walls of said wave guide tube and the cam blocks into opposition to the second movable die section; and means to actuate said operating head to bend said wave guide tube.

5. In an apparatus for bending a wave guide tube, a base, external dies mounted thereon, reciprocable means for moving said external dies into engagement with external surfaces of opposite walls of a wave guide tube, internal die means extending into said wave guide tube and having first sides thereof formed complementary to a first of said external dies to engage an internal surface of a first wall of the wave guide tube adjacent said first external die, second sides of said internal die means having concave arcuate portions positioned inside the wave guide tube, forming cams nested in said concave arcuate portions for engaging an internal surface of a second wall of said wave guide tube adjacent a second of said external dies, and operating members actuated by said reciprocable means to pivot said forming cams into engagement with said second wall of the wave guide tube.

6. Apparatus for bending a wave guide tube, which comprises reciprocable external dies operable for engaging opposite external walls of a wave guide tube, a plurality of mutually cooperating pivotable cams, support means for holding the cams within the wave guide tube in positions opposite to and cooperating with one of said external dies, means for engaging said external dies designed also to support the interior of the wave guide tube adjacent to another of said external dies, and means operable when the external dies move into engagement with the external walls for simultaneously actuating the cams pivotally to cause the cams to engage the interior of the tube adjacent to said first-mentioned external die so as to cooperate therewith to modify the configuration of the wave guide tube.

7. The method of producing a modified, generally V-shaped bend of substantially uniform internal cross section in rectangular wave guide tubing, which comprises preforming a generally arcuate-shaped bend of a desired angle in a section of the wave guide tubing, flattening a portion of the convex wall of the bent wave guide tubing, said flattened portion being disposed symmetrically with respect to the center of the initial bend, to produce an outer angular surface while supporting the tube internally and thereby to prevent any distortion in the configuration of the wave guide tube, and flattening a lesser portion of the concave wall of the wave guide tubing, said last-mentioned flattened portion being disposed symmetrically about the center of the initial bend and substantially parallel to said first-mentioned flattened portion to produce an inner angular surface while supporting the tube externally and internally to prevent any
other change in the configuration of the wave guide tubing.

8. The method of producing a modified, generally V-shaped bend of substantially uniform internal cross section in rectangular wave guide tubing, which comprises preforming a generally arcuate-shaped bend of a desired angle in a section of the wave guide tubing, flattening a portion of the convex wall of the bent wave guide tubing, said flattened portion being disposed symmetrically with respect to the center of the initial bend, to produce an outer angular surface while supporting the tube externally and internally to prevent any other change in the configuration of the wave guide tube, flattening a lesser portion of the concave wall of the wave guide tubing, said last-mentioned flattened portion being disposed symmetrically about the center of the initial bend and substantially parallel to said first-mentioned flattened portion, to produce an inner angular surface while supporting the tube externally and internally to prevent any other change in the configuration of the wave guide tubing, and forming concave indentations extending transversely of the tube along the corners of the outer angular surface of the wave guide tubing.

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