Dec. 9, 1969 S. K. ALTES 3,482,308

METHOD FOR MILLING WAVEGUIDE BENDS

Filed Oct. 25, 1966 2 Sheets-Sheet 1

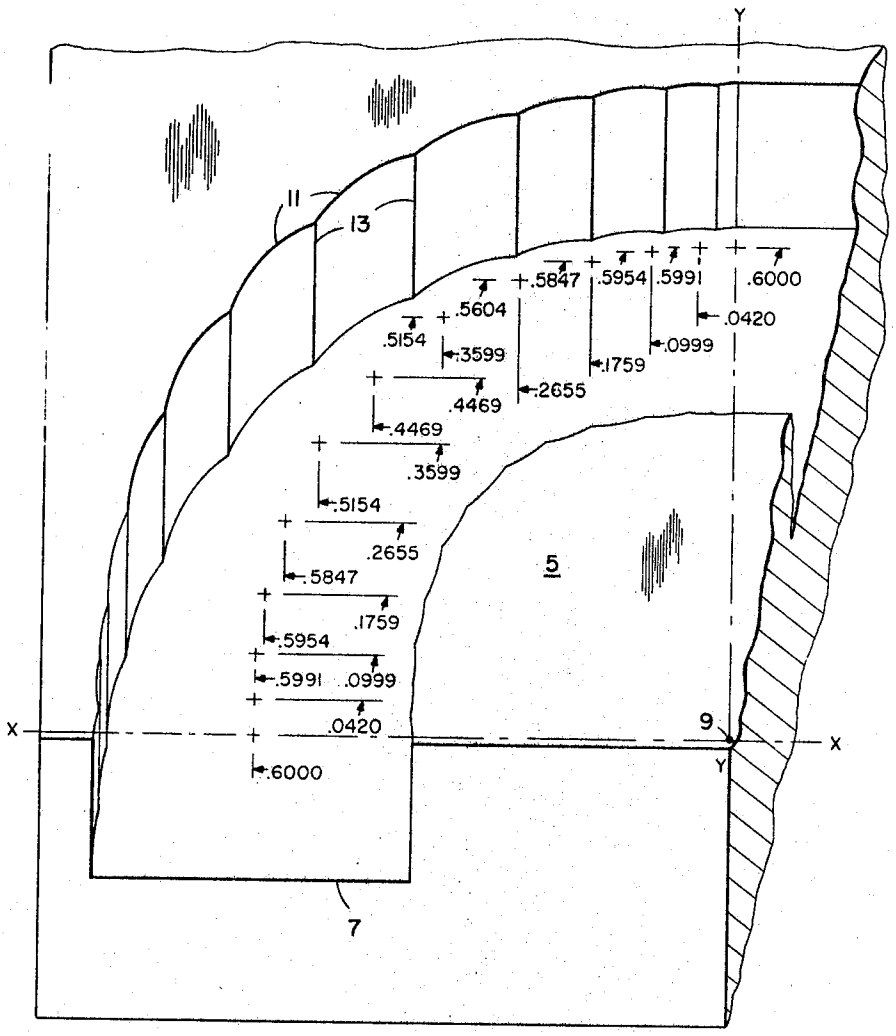


FIG. 2

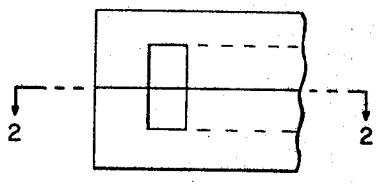


FIG. 1

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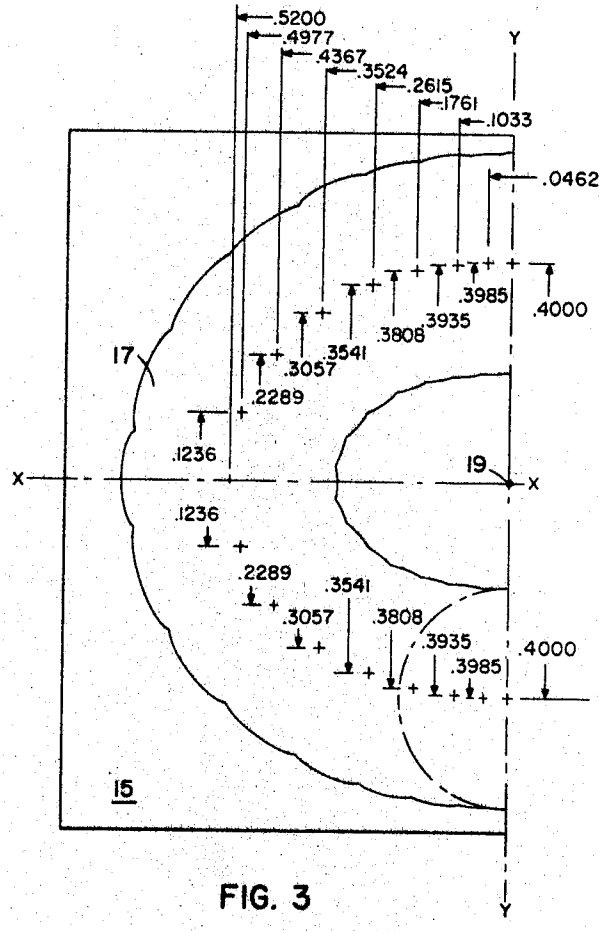


FIG. 3

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METHOD FOR MILLING WAVEGUIDE BENDS

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U.S. Cl. 29—600 3 Claims

ABSTRACT OF THE DISCLOSURE

A method for making milled waveguide bends and more specifically to a method for milling a close approximation to smooth waveguide bends using an endmilling machine.

Digital computer controlled milling machines are finding increased application in precision milling. One of the simpler machines, such as the Clereman Spindlemaster which can only move in one coordinate direction at a time, has been used to produce a desirable waveguide bend which has scalloped sides.

For broadband low reflection waveguide bends, gradual curves are desirable. By using an endmill with a diameter equal to the waveguide dimensions which the bend must match, it has been found that a bend can be made with slightly scalloped sides. As long as the distance between the ridges of the scallops is small in comparison to the wavelength of the wave to be propagated, the effect of the scalloped walls on the propagated wave is negligible.

It is, therefore, an object of this invention is provide a method of milling a waveguide bend that has a very desirable reflection coefficient.

Another object of this invention is to provide a method of milling a waveguide bend which approximates a smooth bend, but is less expensive to manufacture than a smooth bend.

Briefly, the invention is a method for milling a bend for a waveguide from work pieces of material suitable for transmission of electromagnetic waves, and said method including two substantially identical work pieces, placing each of said work pieces in an endmilling machine having an endmill with a diameter equal to the desired opening of the waveguide, milling a groove in each of the work pieces by positioning the endmill at a plurality of predetermined points in an X and Y direction from a predetermined reference point and plunging the endmill into the work piece at each point to the same depth defined by the necessary size of the waveguide, and securing the milled work pieces together with the grooves mated together to thereby form a waveguide bend.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein:

FIGURE 1 is an elevational view of a waveguide bend according to the invention;

FIGURE 2 is a pictorial view taken along line 2—2 of FIG. 1 and showing milling position centers; and

FIGURE 3 is a plan view of one half of a milled 180° bend and showing milling position centers.

Referring now to FIGURE 2, there is shown an aluminum alloy work piece **5** having a milled groove **7** forming a ninety degree bend which is milled with a .2000 unit radius endmill. The groove is milled by positioning an endmill, not shown, either manually or by a program tape cut for a computer controlled milling machine, at thirteen different positions about a reference point **9** which defines the origin of X and Y coordinates as shown in FIGURE 2. Each of the milling positions are predetermined and measured in units as shown in the drawing, from the X and Y coordinates.

The mill is separately positioned at each milling position and then plunged into the work piece to a predetermined depth depending on the required size of the waveguide opening. This leaves scallops **11** in the sides of the waveguide, and this configuration of the waveguide has been found to be very desirable. As long as the distance between ridges **13** is small in comparison to the wavelength, the effect of the scalloped walls is neglibible. The bend is completed by milling a second work piece **5** to the same dimension and attaching the two parts in aligned relation by dip-brazing, screws, epoxy cement or in some other conventional manner (see FIGURE 1).

Referring now to FIGURE 3, there is shown an aluminum alloy work piece **15** having a milled groove **17** forming a one-hundred and eighty degree bend that has been milled with a .2000 unit radius endmill. The groove is milled as discussed above for the ninety degree bend with the exception of the number of milling positions being seventeen as shown in FIGURE 3 by dimensions. The positions are measured from X and Y coordinates with the origin at a reference point **19.**

The particular groove **17** has an uneven radius of curvature. The inverse of the radius of curvature is small at the two ends of the bend and larger in the center. The spacing between successive plunging points is also smaller at the ends than in the center, in order to make all parameters change in a gradual fashion.

A dual one hundred and eighty degree bend constructed in this fashion had a reflection coefficient of less than 1.05 from 8,900 mc. to 12,400 mc.

It will be understood that the invention may be variously modified and embodied within the scope of the subjoined claims.

What is claimed is:

1. A method for milling a bend for a waveguide from pieces of solid conductive material suitable for transmission of electromagnetic waves comprising: providing two substantially identical work pieces; placing each of said work pieces in an endmilling machine having an endmill with a diameter equal to the desired opening of said waveguide; milling a groove in the form of a bend in each of said work pieces by positioning said endmill at a plurality of predetermined points in a X and Y direction from a predetermined reference point and plunging said endmill into said work piece at each point to the same predetermined depth spacing said plurality of predetermined points apart so that an uneven radius of curvature will be formed in said work pieces wherein the spacing between said plurality of predetermined points is smaller at the ends than in the center, said milled portions thereby forming scalloped edges such that the distance between the ridges of said scallops is substantially

shorter than the wavelength of said electromagnetic waves to be propagated through said bend; and securing the milled work pieces together to form a waveguide bend.

2. A method for milling a bend for a waveguide as set forth in claim 1, and further including, taking said reference point at one corner of said work piece that is generally rectangular and milling a ninety degree bend by milling at a plurality of thirteen predetermined positions.

3. A method for milling a bend for a waveguide as set forth in claim 1, and further including, taking said reference point at approximately the middle of one edge of said work piece that is generally rectangular, and milling a one hundred and eighty degree bend by milling at a plurality of seventeen predetermined positions.

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