July 19, 1966 H. A. HANEMANN, JR., ETAL 3,261,078

METHOD OF MANUFACTURE OF WAVEGUIDE COMPONENTS

Filed Aug. 9, 1962

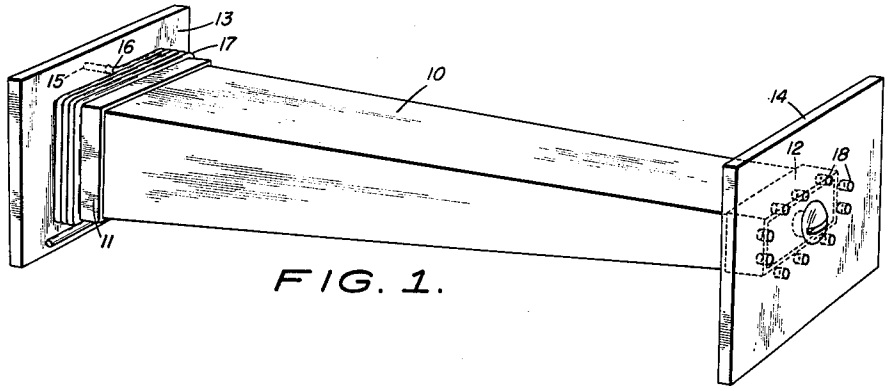


FIG. 1.

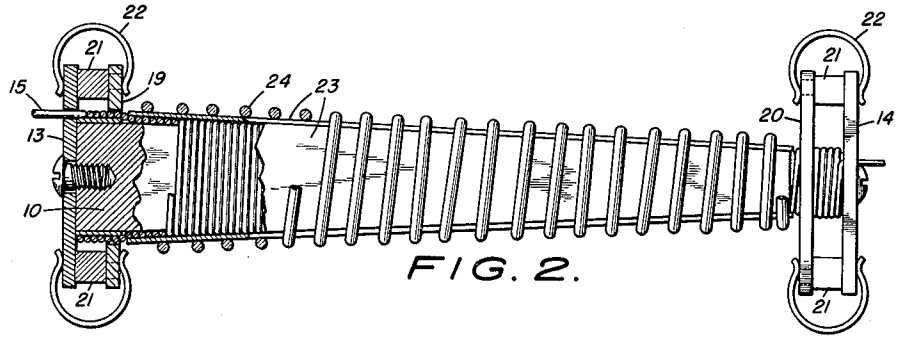


FIG. 2.

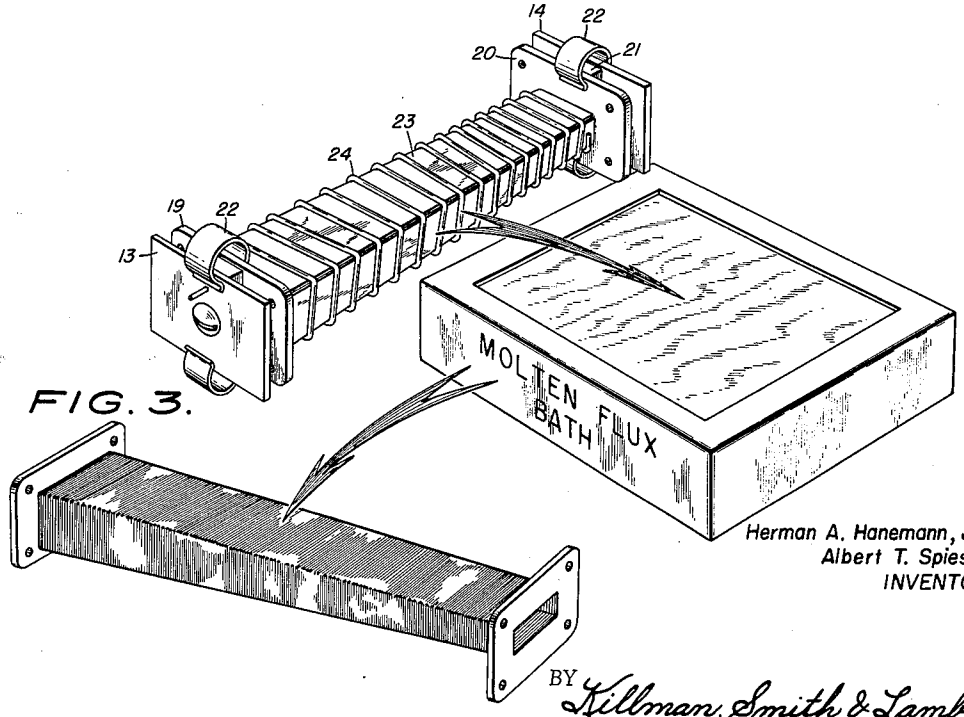


FIG. 3.

Herman A. Hanemann, Jr.
Albert T. Spiese
INVENTORS

BY Killman, Smith & Lamb
ATTORNEYS

United States Patent Office 3,261,078 Patented July 19, 1966

3,261,078

METHOD OF MANUFACTURE OF WAVEGUIDE COMPONENTS

Herman A. Hanemann, Jr., New Cumberland, and Albert T. Spiese, York, Pa., assignors to The Bendix Corporation, York, Pa., a corporation of Delaware

Filed Aug. 9, 1962, Ser. No. 215,835
3 Claims. (Cl. 29—155.5)

The present invention relates to the manufacture of hollow articles of complex shape and is particularly directed to the manufacture of waveguide transition sections, junctions, couplers and the like.

Tubular waveguides of various electrical characteristics are widely employed as low loss transmission lines for radio frequency energy in the region lying generally below 30 centimeters wavelength. The waveguides frequently are formed with circular, rectangular, ridged or alternative interior cross-sections, depending on the particular qualities sought or secondary considerations such as the bulk and weight of the assembly. Very often it is necessary to effect a transistion from one waveguide form to another while still maintaining the closed, continuous walls characteristic of the structure. Transitions are normally accomplished by smoothly evolving the internal shape from that of one form to that of the other without introducing abrupt changes likely to cause reflections.

In addition to transition sections, use is often made of various junctions and couplers which provide means for coupling energy from one waveguide to another with various power ratios or with directional characteristics which depend upon the direction in which energy flows.

Transitions, junctions and couplers differ in appearance from the usual waveguide in the non-uniformity of their interior cross-sections. Uniform cross-section waveguide can be produced by any of the methods common in the manufacture of tubing. Transitions, junctions and other waveguide elements of non-uniform cross-section are produced by casting, by assembly and by electroforming. Each of these prior methods suffer some disadvantages especially where production runs are small or where final design must be determined by experimentation. Tooling costs generally eliminate casting methods for small quantity or experimental production. Assembly of a junction or transition from plates often involves complex patterns and intricate forming operations. Electroforming requires considerable time for building up appropriate wall thicknesses in a product and further requires that a form be made for each article produced.

One of the objects of the present invention is to provide a process for the manufacture of complex waveguide shapes involving only relatively cheap reusable forms which may be constructed by any competent machinist.

Another object is to provide a process for the manufacture of waveguide components, the final design of which may require experimentation.

Still another object is to provide a process for the manufacture of waveguide components affording accurate dimensional control and good electrical characteristics in the finished product.

Other objects and many attendant advantages will become apparent as an understanding of the invention is gained through study of the following detailed description and the accompanying drawings.

Briefly, the process of the invention comprises the steps of preparing a form or mandrel having an exterior shaped and dimensioned to correspond to the desired interior of the waveguide component. Aluminum or copper wire is then wound on the mandrel in closely abutting turns. The mandrel with windings in place is then subjected to a brazing operation, preferably of the immersion bath or dip type, which welds the elemental structure into a rigid,

unitary device having continuous, virtually smooth side walls. As a final step, the mandrel or form is removed and excess material is trimmed away, if required.

In the drawings:

FIG. 1 is a perspective of a mandrel shaped to provide a transition from large to small rectangular waveguide and illustrating the start of the winding of wire upon the mandrel;

FIG. 2 is an elevation, partially in section, of the mandrel of FIG. 1, showing the winding and end flanges of the transition in place and filler metal applied preparatory to dip brazing; and

FIG. 3 illustrates the step of dip brazing, the assembly of FIG. 2, and the finished article after dipping and removal of the mandrel.

Referring to FIG. 1 of the drawings, the process will be described with reference to the construction of a very simple transition shape. It will be appreciated, however, that the process is not limited to the particular transition illustrated and may be widely varied in shape. It is necessary later in the process to withdraw the mandrel from the component so that ordinary considerations for draft should apply at the time the mandrel is designed. It may be necessary to split the mandrel into two or more sections or to construct the component from several sub-assemblies manufactured in accordance with the invention.

The mandrel is preferably machined from solid stainless steel stock. The mandrel, clamps and reusable fixtures or forms are black oxydized by heating in air at a temperature of about 1000° F. for about one-half hour prior to use. The oxydized surfaces serve as a mold release with no further treatment for that purpose being required.

As seen in FIG. 1, the mandrel **10** is prismoidal with a rectangular cross-section at the starting end corresponding to the internal cross-section of a large size rectangular waveguide, tapering to a smaller rectangular cross-section at the finish end corresponding to the dimensions of smaller size waveguide. Both start and finish ends of the mandrel are provided with short, straight wall sections **11** and **12**, upon which waveguide coupling flanges are later pressed. The mandrel **10** is provided with removable end plates **12** and **13**, also of oxydized stainless steel, which serve to hold the wire and flanges or other fittings in position during brazing and act as gauge posts during winding.

The mandrel **10** with end plates attached is inserted in a lathe or similar turning device to facilitate winding the wire forming the base metal of the component sidewalls. One end **15** of a stock of wire of sufficient length to wrap the mandrel continuously from end to end is inserted in a hole **16** in end plate **13** and the mandrel is commenced turning. As the mandrel turns the wire is tensioned and formed to lay upon the mandrel in closely conforming tightly abutting turns, as seen at **17**. When the mandrel is filled, the wire is cut off from stock and a stub end is passed through one of the holes **18** in end plate **14** positioned about the mandrel periphery, temporarily securing the wire to the mandrel. The mandrel is then removed from the lathe.

Referring to FIG. 2, end pieces **13** and **14** are removed and the wire is held in place on the mandrel while waveguide flanges **19** and **20** are fitted. End pieces **13** and **14** are reinstalled. Spacer blocks **21** and U-shaped clips **22**, both of oxydized stainless steel, support flanges **19** and **20** prior to brazing, while the wire is again held by the holes **16** and **18** in end plates **13** and **14**. The outer surface of the wire wrap is covered by filler metal **23** in the form of shim stock which is held in place by a loose wrap of filler metal in the form of wire **24**. The entire structure of FIG. 2 is then immersed in a bath of molten flux with liquefies the filler metal, causing it to flow by capillary action into the interstices of the base metal

wrap and flanges. Finally the article is removed from the bath, the mandrel and holding pieces are removed and the article is cleaned. The finished article is shown in FIG. 3.

The dip brazing process is the preferred method of bonding components prepared in accordance with the invention. Although dip brazing is not of itself a part of the invention, the speed of production and uniformity of results enabled thereby warrant further description. It will be appreciated that the process varies according to the base metal chosen. Because of the wide popularity of aluminum as a waveguide material, the process will be described with particular reference to the steps involved in dip brazing that material.

The base metal can be selected for a number of available aluminum alloys melting in the range of 1140–1215° F. Filler metals are selected from alloys having melting points from 75–100° F. lower than the base metal. The base metal stock used in winding the mandrel, flanges or other elements to be brazed are thoroughly cleaned prior to immersion, or more conveniently, prior to assembly for immersion. The fluxes employed in the bath are mixtures of sodium fluorides and chlorides available in proprietary formulations from various aluminum producers; for example, Flux No. 33 a product of the Aluminum Company of America. The flux is melted in a suitable refractory pot and brought to a closely controlled temperature of about 1100° F. The parts to be brazed, for example the assembly of FIG. 2, are preheated to a temperature of about 975° F. for approximately one-half hour and then immediately submerged in the flux bath for from 30 to 180 seconds. Following a short period of cooling at room temperature, the assembly is cleaned in boiling water, end plates and clips are removed and the component, with mandrel in place, is returned to the preheat oven. In the oven the component is positioned to allow any residual flux to run off. Reheating the component also expands it to permit ready removal of the mandrel. After the component is stripped from the mandrel, the component is cleaned and trimmed where necessary.

Waveguide components produced in accordance with present invention exhibit excellent mechanical and electrical properties. Mechanically, the components are very nearly equal in strength to similar components produced by casting. Electrically components made by the process of the invention have been shown to exceed the performance of similar components produced by electroforming.

While the invention has been described with reference to a particular transition worked in aluminum, it is obvious that transitions of other forms, junctions or other components may be likewise produced. Metals other than aluminum may be employed or the cross-section of the wire stock may be other than circular. It should be understood, therefore, that the invention may be practiced otherwise than as specifically disclosed without departing from the scope of the appended claims.

We claim:

1. The method of manufacture of hollow waveguide components, comprising preparing a mandrel with an exterior shape corresponding to the internal configuration desired of the waveguide component, winding a tightly fitting spiral of metal wire upon said mandrel, assembling flanged fittings to the terminal ends of said spiral, securing said spiral and fittings to said mandrel by means of removable clamps, placing filler metal upon the outer surface of said spiral and adjacent said fittings, immersing said mandrel with said spiral and fittings clamped thereto in a bath of flux at a temperature sufficiently elevated to liquefy said filler metal but below the melting point of said metal wire, removing said mandrel, spiral, fittings and adherent filler metal from said bath, cooling said mandrel, spiral and fittings to cause the adherent filler metal to solidify and thereby secure said spiral and said fittings in rigid form, and removing said clamps and mandrel from said rigid spiral.

2. The method of claim 1 with the additional step of preheating said mandrel, spiral, fittings and filler metal to a temperature slightly below the melting point of said filler metal before performing said immersion step.

3. The method of manufacture of hollow waveguide components, comprising preparing a form shaped to the desired interior of the waveguide component, winding upon said form a spiral of base metal wire, said spiral having contiguous non-intermeshing turns, the resultant structure being flaccid and incapable of maintaining shape without internal support,

constraining said spiral to the shape of said form by removable clamps,

placing upon said spiral filler metal which is fusible at a temperature below the melting point of said base metal and is capable of adhering to said base metal,

immersing said form with said spiral, filler metal and clamp in place thereon, in a bath of molten flux maintained at a temperature above the melting point of said filler metal and below the melting point of said base metal whereby said filler metal is liquefied and flows into the interstices that exist between turns of said spiral,

removing said form together with said spiral, clamps and adherent filler metal from said bath,

cooling said removed form, spiral, clamps and adherent filler metal to cause solidification of said filler metal and unification of the turns of said spiral, and

stripping the unified structure from said form.

References Cited by the Examiner

UNITED STATES PATENTS

699,592	5/1902	Thompson	29—502
2,146,823	2/1939	Karmazin	29—502
2,166,109	7/1939	Karmazin	29—502
2,258,836	10/1941	Willner	29—502
2,842,841	7/1958	Schnable et al.	29—498
3,008,104	11/1961	Scapple et al.	29—454

FOREIGN PATENTS

742,490	3/1933	France.

JOHN F. CAMPBELL, *Primary Examiner.*

J. W. BOCK, J. M. ROMANCHIK, JR.,
Assistant Examiners.