Dec. 29, 1970 R. T. HUMER 3,550,263

METHOD OF FABRICATING TWT HELICES

Filed Aug. 27, 1968

FIG. 1

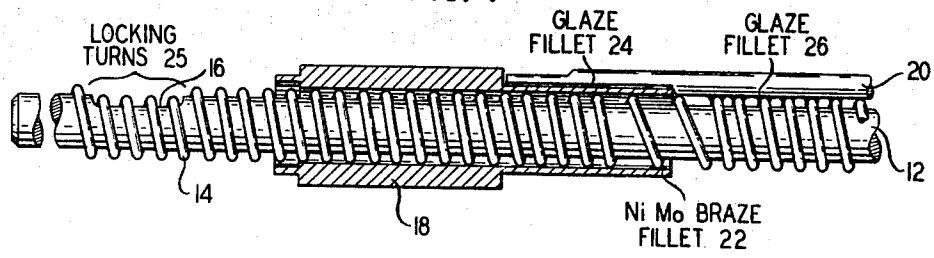



FIG. 2

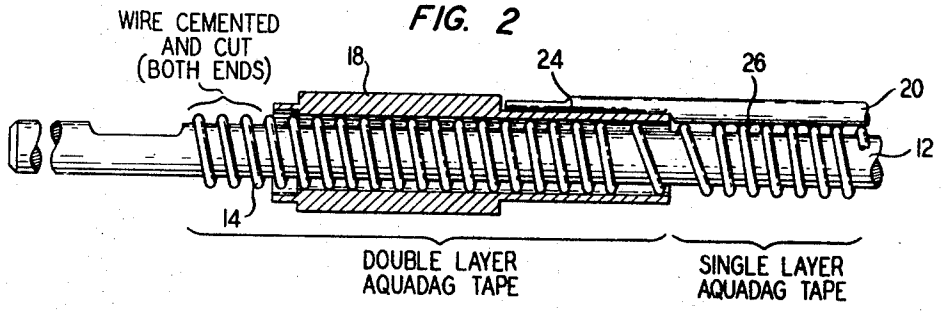
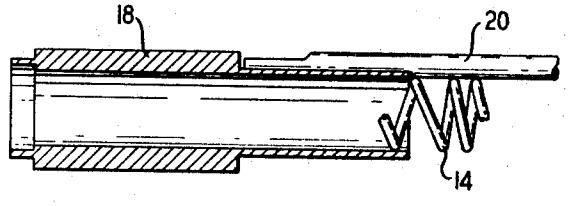



FIG. 3




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United States Patent Office 3,550,263
Patented Dec. 29, 1970



3,550,263

# METHOD OF FABRICATING TWT HELICES

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Filed Aug. 27, 1968, Ser. No. 755,611
Int. Cl. H01p 11/00; H01g 13/00
U.S. Cl. 29—600 7 Claims

## ABSTRACT OF THE DISCLOSURE

In the manufacture of the helix assembly for a traveling wave tube the contraction of helix support rods, during the cooling cycle and after the glaze has solidified at the couplers, causes fractures in the glaze joint or in the support rods themselves. The primary cause of the fractures, it has been found, is the lack of freedom of the coupler to move with the shrinking support rods. This restraint is eliminated in the method of the present invention which comprises the steps of: cementing at least one helix turn to a mandrel after the helix has been brazed to the couplers; removing helix turns locking the helix to the mandrel; securing preglazed support rods into a glazing fixture; and glazing the helix and couplers to the rods in a single furnace run.

## BACKGROUND OF THE INVENTION

This invention relates to a method of fabricating the helix assembly of a traveling wave tube.

In the prior art, traveling-wave tube amplifiers and oscillators have employed a slow-wave transmission circuit and an electron beam in interacting relationship with an electromagnetic wave propagating along the slow-wave circuit. In general, these tubes include an evacuated envelope, an electron gun disposed at one end of the envelope for producing the electron beam, an anode electrode for collecting the electrons, and a supporting arrangement for holding the slow-wave structure in alignment with the electron beam. The slow-wave structure which is usually in the form of a relatively long slender conductive helix, must be rigidly supported and accurately aligned with the electron gun from which the beam of electrons is projected in order to maintain alignment of the electron beam with the helix. Accurate collimation of the electron beam, with respect to the helix, enables the electron beam to interact with the fields of the electromagnetic wave over the complete length of the helix to provide maximum interaction therebetween.

Many forms of supporting arrangements have been proposed for supporting the helix whenever it is utilized as the slow-wave circuit of a traveling-wave device. The most widely used arrangement includes a conductive helix mounted in a traveling-wave tube with three or four insulating rods, such as glass or ceramic for example, attached externally along the length of the helix by affixing each rod to the turns of the helix by "glazing." The glazing material is usually glass-like powdered material mixed with a liquid binder to facilitate applying the glass-like material to the rods. The glass has a coefficient of expansion as close to that of the helix and support rods as possible. A thin film of the glass-like powdered material is applied to the support rods before the rods are glazed to the helix. In the instance where the supports are glass, the glass-like material may be omitted. The support rods are secured lengthwise in spaced positions about the circumference of the helix and fired at a temperature sufficient to glaze the rods to the helix. The resulting slow-wave structure is a unitary one wherein the helix is rigidly supported and may be assembled in the vacuum envelope of a traveling-wave tube.



The arrangement discussed above has several disadvantages. From a mechanical point of view, it has been found that the contraction of the rods, during the cooling cycle and after the glaze has solidified at the couplers, causes fractures in the glaze joint or in the support rods themselves. The primary cause of the fractures is the lack of freedom of the coupler to move with the shrinking support rods.

Furthermore, from a method point of view, it is customary to glaze the helix to the rods in one furnace run at about 1200° C., whereas the couplers and the rods are glazed in a subsequent furnace run at about 850° C. Thus, in the event of damage to the helix-rod glaze caused by subsequent handling, it is impossible to re-run at 1200° C. without destroying the low temperature coupler-rod glazer. Consequently, helix assemblies so damaged cannot be repaired and therefore represent a total loss.

## SUMMARY OF THE INVENTION

The method in accordance with the present invention eliminates coupler-rod restraint thereby greatly reducing the aforementioned fractures and, in addition, the fabrication is accomplished in a single high temperature furnace run thus allowing an immediate furnace re-run to repair damage to the glaze caused by subsequent handling. This method comprises the steps of (1) cementing at least one helix turn to a mandrel after a helix-coupler braze has been made; (2) removing locking turns (if any) in the flats; (3) cementing preglazed support rods into a glazing fixture; and (4) glazing the helix and couplers to the rods in a single high temperature furnace run. In addition, in the event of damage to the glaze caused by subsequent handling, the method further comprises the additional step of immediately re-glazing the helix and couplers in another high temperature furnace run.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with various features and advantages, can be easily understood from the following more detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a partial schematic of a helix assembly before removal of the locking turns;

FIG. 2 is a partial schematic of a helix assembly after removal of the locking turns and showing in addition the application of transfer tape to facilitate handling; and

FIG. 3 is a partial schematic of a completed helix assembly.

## DETAILED DESCRIPTION

Before discussing the method of the present invention, it will be helpful to consider first, for purposes of comparison, the technique employed in the prior art which generally comprises the steps of, with reference to FIG. 1, (1) covering a tungsten mandrel **12** with a layer of carbon .0005 inch thick (not shown) typically by means of a transfer tape to provide a clearance between the mandrel **12** and helix to facilitate removal of the mandrel upon completion of the assembly; (2) winding on the mandrel **12** a molybdenum wire helix **14** at a desired pitch and length, a portion of the helix turns, termed locking turns **25**, being positioned in a flat **16** in the mandrel **12**; (3) threading couplers **18** (only one of which is shown) over each end of the helix **12**; (4) cementing the couplers in place; (5) brasing the couplers **18** to the helix **14** at a point **22** where the helix enters the coupler using a Ni-Mo alloy with liquidus of 1320° C.; (6) polystyrene cementing preglazed support rods **20** (only one of which is shown) into a glazing fixture (not shown); (7) aligning the helix-coupler subassembly to the rods **20**; (8) glazing the helix **14** to the rods **20** in a high temperature furnace run at 1200° C., thus forming a glaze

fillet **26**; (9) glazing the couplers **18** to the rods **20** in a low temperature furnace run at 850° C., thus forming a glaze fillet **24**. With the excess helix turns clipped and the mandrel removed, the completed assembly appears, as shown in FIG. 3.

This technique of manufacture is complicated by the fact that at the temperatures necessary for glazing the assembly, the differences in thermal expansion of the various materials becomes a critical design factor. This is most evident in the glaze fillet **24** formed between the coupler **18** and the support rods **20**. During the high temperature glazing run, the rods typically expand in length by about 19 mils. During the cooling cycle following this run, the contraction of the rods causes fractures in the glaze fillets or in the support rods themselves. It has been found that the primary cause of the fractures is the lack of freedom of the couplers to move with the shrinking rods, i.e., the rods are glazed to the helix (step 8), the helix is brazed to the couplers (step 5) and the helix is restrained from moving by the locking turns **25** in the flats **16**.

In addition, the prior art technique disadvantageously requires two furnace runs (steps 8 and 9) which entails additional expense and prevents repair of the high temperature glaze fillets damaged by subsequent handling. Two furnace runs are required because the coupler-rod joint (step 9) cannot tolerate the 19 mil expansion caused by the high temperature run. Again, this is due to the aforementioned lack of freedom of the couplers to move with the rods. Consequently, the coupler-rod joint is formed at a lower temperature and produces typically only an 8 mil expansion. Consider what would happen if the high temperature rod-helix glaze fillet **26** were fractured in a completed assembly. It could not be repaired by a subsequent high temperature run without melting the low temperature glaze fillet **24**. Furthermore, it could not be repaired by a subsequent low temperature run because the temperature would be insufficient to affect the high temperature glaze fillet.

To eliminate the restraint upon the motion of the couplers, the following detailed method is set forth in accordance with the invention: Steps (1) through (5) are basically as set forth in the prior art method. However, after step (5) the following steps are performed: (5*a*) polystyrene cementing at least one helix turn to the mandrel, as shown in FIG. 2; (5*b*) after the cement has hardened, removing the locking turns **25** (FIG. 1) and excess turns. Steps (6) and (7) follow the prior art whereas the two furnace runs, steps (8) and (9) are replaced by step (8*a*), a single high temperature (1200° C.) run which forms both the rod-helix glaze and the rod-coupler glaze and in addition burns off (at 150° C.) the cement which binds the helix to the mandrel.

During the cooling cycle, there being no locking turns nor cement (which burns off at 150° C.) to restrain coupler motion, the incidence of fracture of the glaze joints on the rods themselves is greatly reduced. Consequently, 95% yield using this technique of manufacture is not uncommon.

Furthermore, should the glaze be damaged by subsequent handling, the assembly can be readily repaired by an immediate re-run of the high temperature furnace operation, step (8*a*). One difficult handling operation is the removal of the mandrel. Typically, only a 1 mil clearance exists between the mandrel and helix after the carbon has burned off in step (8*a*). To reduce the incidence of fracture caused by the removal of the mandrel, step (1) may be modified to apply a double layer (~.0010 in.) of carbon



(aquadag) on the mandrel in the region of the coupler, as shown in FIG. 2.

In summary, the basic steps of the invention are: (1) winding wire on a mandrel to form a helix; (2) affixing a coupler over each end of the helix; (3) bonding the coupler electrically to the helix; (4) cementing at least one turn of the helix to the mandrel; (5) affixing support rods in alignment with the helix and the couplers; (6) glazing the helix to the rods and the couplers to the rods at a temperature high enough to burn off the cement binding the helix to the mandrel.

It is to be understood that the above-described method is merely illustrative of the application of the principles of the invention. Numerous other methods may be devised by those skilled in the art without departing from the spirit and scope of the invention.

I claim:

**1.** The method of fabricating a traveling wave tube helix assembly comprising the steps of

(a) winding wire on a mandrel to form a helix;

(b) affixing couplers over each end of the helix;

(c) bonding the couplers electrically to the helix;

(d) cementing at least one turn of the helix to the mandrel;

(e) affixing support rods in alignment with the helix and the couplers; and

(f) glazing the helix to the rods and the couplers to the rods at a temperature high enough to burn off the cement binding the helix to the mandrel but low enough not to destroy the coupler-helix bond.

**2.** The method of claim **1**, wherein the glaze formed is subsequently fractured, including after the glazing step (f) the additional step of

(g) reglazing the helix to the rods and the couplers to the rods.

**3.** The method of claim **1** including before the winding step (a) the preliminary step of

(a′) covering the mandrel with a layer of carbon of thickness of the order of .0010 inch in the region under the couplers.

**4.** The method of claim **1** wherein said mandrel includes a flat and said winding step (a) includes winding a portion of the helix turns, termed locking turns, into the flat, and including after the cementing step (d) the additional step of (d′) removing the locking turns after the cement has hardened.

**5.** The method of claim **1** wherein said bonding step (c) comprises brazing the couplers to the helix.

**6.** The method of claim **5** wherein said helix comprises a molybdenum alloy and said brazing step is performed with a Ni-Mo alloy having a liquidus of about 1320° C.

**7.** The method of claim **1** wherein said glazing step is performed in a furnace at a temperature of about 1200° C.


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U.S. Cl. X.R.

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