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METHOD OF MANUFACTURING A MULTI-CAVITY ELECTRON BEAM TUBE, THE TUBE COMPRISING MULTIPLE RESONATOR MODULES

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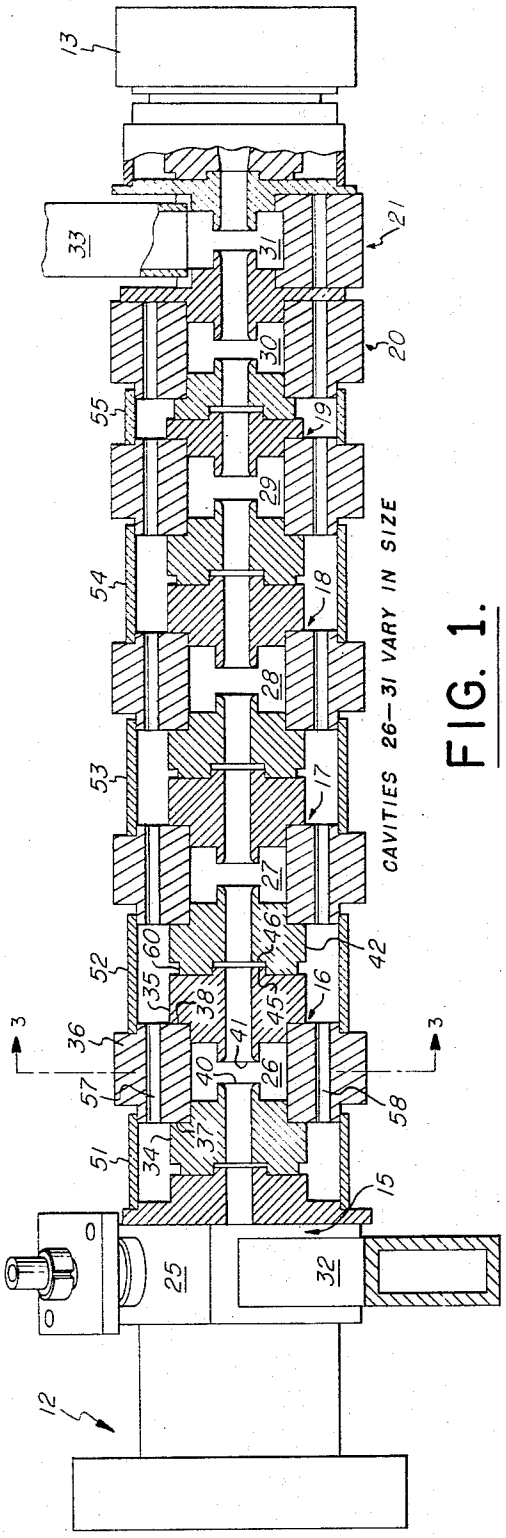


FIG. 1.

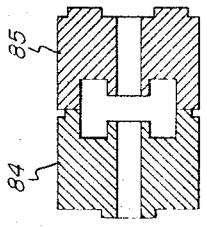


FIG. 4.

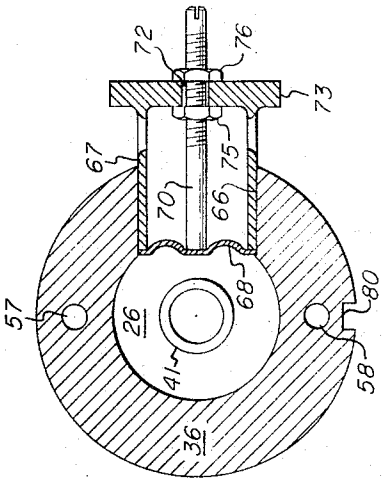


FIG. 3.

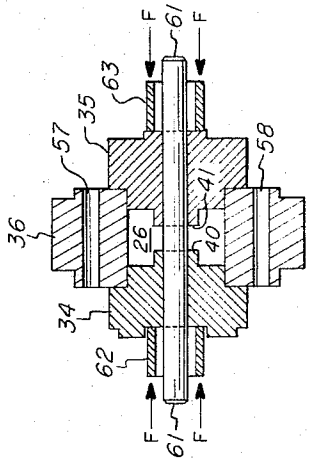


FIG. 2.

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METHOD OF MANUFACTURING A MULTI-CAVITY ELECTRON BEAM TUBE, THE TUBE COMPRISING MULTIPLE RESONATOR MODULES

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The present invention relates to multi-cavity electron beam tubes and more particularly to a simple and economical manner of constructing such a tube.

The successful and economical manufacture of multi-cavity electron beam tubes such as klystron tubes depends upon the accuracy with which the individual cavities of a completely assembled tube can exhibit their desired electrical characteristics such as Q values and resonant frequencies. Most tubes of these types are constructed from a great many component parts, and as a result of the cumulative effects of dimension variations in various component parts and dimensional errors arising during assembly of the tube, the completed tube may operate with electrical characteristics so different from the desired characteristics that expensive and difficult reworking of the assembled tube may be required, or the tube may have to be discarded completely. Extreme caution and attention to dimensional tolerances in the component parts and in the assembly procedure of the tube greatly adds to the cost of the tube and cannot always be permitted. The addition of cavity tuners having an appreciable frequency tuning range to help compensate for the above difficulties is not always possible because of mechanical and electrical limitations.

It therefore is an object of the present invention to provide a multi-cavity electron beam tube constructed in such a manner as to permit accurate pretuning of individual cavities.

A further object of this invention is to provide a multi-cavity electron beam tube constructed in such a manner as to permit the preassembly and pretuning of individual cavities of the tube.

Another object of this invention is to provide a multi-cavity electron beam tube that is constructed in a manner to permit a plurality of preassembled and pretuned cavities to be finally assembled into the tube body in a single operation that does not disturb the tuning of the cavities.

A further object of the invention is to provide a simple and economical manner of constructing a multi-cavity electron beam tube.

Another object of this invention is to provide a rugged and reliable klystron tube that is easily constructed from a stock of standard and interchangeable parts.

These and other objects and advantages of the present invention are achieved by providing a tube body structure comprised of a plurality of pairs of first and second solid, longitudinally-extending end members that are coaxially positioned along the tube axis. The adjacent faces of each pair of first and second end members are disposed in spaced-apart relationship and an annular enclosing member is secured in a vacuum-tight manner about the peripheries of the adjacent faces of each pair, thereby forming an electromagnetic wave cavity therebetween. The adjacent faces of successive pairs of end members are secured in abutting relationship to complete the vacuum-tight seal for the body portion of the tube and to form beam drift tube between successive cavities.

The invention will be described by referring to the accompanying drawings wherein:

FIG. 1 is a partial sectional view showing a completely assembled multi-cavity klystron amplifier tube constructed in accordance with the present invention;

FIG. 2 is a sectional view of an individual cavity unit constructed in accordance with this invention, and further illustrates a means for pretuning the cavity unit;

FIG. 3 is a transverse sectional view taken at section 3—3 of FIG. 1 and showing an arrangement of a trim tuner, cut away in the sectional view of FIG. 1, for slightly tuning a cavity of the tube; and

FIG. 4 is a sectional view of an alternative embodiment of an individual cavity unit constructed in accordance with the teachings of this invention.

Referring in detail to the drawings, a multi-cavity klystron tube amplifier is illustrated in FIG. 1 and is comprised of a conventional electron gun 12 that forms and directs a beam of electrons along the longitudinal axis of the tube. An electron beam collector 13, which also may be of conventional design, is located at the opposite end of the tube to terminate the electron beam. The body portion of the tube is comprised of a plurality of individual cavity units 15–21 which are assembled in a vacuum-tight manner along the length of the tube. The cavity units include the respective reentrant cavity resonators 25–31 that are disposed in spaced-apart relationship throughout the length of the body portion of the tube. Electromagnetic wave energy to be amplified may be coupled into the first cavity 15 by means of input waveguide 32, and the amplified electromagnetic waves may be coupled from the last cavity 31 by means of output waveguide 33. Each of the individual cavities 15–21 is similar in construction, and taking cavity unit 16 as an example, it may be seen that the cavity unit is formed as an assembly of first and second solid axially-extending spacing members 34 and 35 which are secured in spaced-apart relationship by means of an annular enclosing member 36 that fits within shoulders 37 and 38 that extend around the peripheries of spacing members 34 and 35. The adjacent faces of spacing members 34 and 35 have centrally positioned extensions 40 and 41 that provide reentrant nibs in the cavity that is formed in the enclosed region between spacing members 34, 35 and annular enclosing member 36. Spacing members 34, 35 and annular enclosing member 36 are secured together in a vacuum-tight manner, as by brazing. Each of the members 34, 35 and 36 are circularly symmetrical about the beam axis and may be machined from blocks of a suitable material such as copper. Spacing member 35 of cavity unit 16 is provided with a centrally positioned stud 45 and spacing member 42 of the adjacent cavity unit 17 is provided with a registering recess 46 to assure the correct alignment of the individual cavity units during final assembly.

Spacing members 34 and 35 are axially apertured throughout their lengths to provide a path for the electron beam through each of the cavity units 15–21. It may be seen that the axial apertures in the spacing members 35 and 42 that are in abutting contact form a beam drift tube between cavities 26 and 27.

In the assembled tube shown in FIG. 1, thin cylinders 51–55 are sealed in a fluid-tight manner between the successive annular enclosing members so as to provide a fluid-tight envelope about the tube. Each of the annular enclosing members, such as member 36, is provided with longitudinally-extending fluid passages 57 and 58 to permit the flow of a fluid coolant in the regions between the outermost envelope formed by thin cylinders 51–55 and the outer circumferences of the spacing members such as 34 and 35. Additional means not illustrated are provided for passing the fluid to an external heat exchanger and pump.

A primary advantage of constructing a multi-cavity klystron tube in the manner illustrated in FIG. 1 is that

each of the cavity units **15–21** may be individually preassembled and pretuned to their desired resonant frequency prior to final assembly into the tube body.

One means for pretuning the individual cavity units prior to final assembly is illustrated in FIG. 2. After the solid spacing members, or cavity end members **34** and **35** have been brazed to annular enclosing member **36** and the assembled cavity unit has been tested for vacuum tightness, a closely-fitting rigid and non-deformable metallic rod **61** is inserted through the axial apertures in spacing members **34** and **35**. Short cylinders **62** and **63**, formed of a rigid, non-yielding material such as steel, is inserted over the two ends of rod **61** and contact the outer faces of spacing members **34** and **35** only in the respective regions immediately surrounding their axial apertures. In the initial assembly of the cavity unit, the members **34–36** are dimensioned to assure that the axial spacing between the reentrant nibs **40** and **41** is slightly greater than ultimately desired to assure that the resonant frequency of the cavity is slightly higher than desired. To reduce the gap width and thus reduce the frequency to the desired value, inwardly directed forces F are applied to the short cylinders **62** and **63** to slightly deform the spacing members in the regions of the nibs **40** and **41** so as to bring the nibs closer together. The resonant frequency of the cavity is then tested until the desired resonant frequency is obtained.

The solid rod **61** extending through the axial apertures prevents the material of spacing members **34** and **35** from collapsing to deform the apertures during the application of forces to cylinders **62** and **63**. This avoids beam intercept problems during operation of the tube.

After each of the individual cavity units has been tested to assure that it meets electrical and mechanical requirements, all of the cavity units then are stacked together and brazed in a single brazing operation to form the completed body portion of the tube. This assembly of the cavity units to form the assembled tube is accomplished by inserting brazing material between the end faces of adjacent cavity untis, such as the adjacent faces of spacing members **35**, and **42**, FIG. 1, and adding further brazing material within the annular notch **60** provided in one of the members.

The type of construction illustrated in the tube of FIG. 1 simplifies the assembly process inasmuch as it minimizes the number of component parts, and enables a relatively unskilled worker to assemble the tube. Each one of the different spacing members, or cavity end members such as members **34** and **35**, and each one of the annular enclosing members such as member **36** may be individually marked or coded so that the workers who assemble the cavity units and who make the final assembly of the tube need only follow a simple procedure of stacking the correctly coded parts, thus minimizing errors that might otherwise arise in the assembly process. Additionally, constructing a tube in the manner described is more economical than in other types of known construction. This results from the fact that each cavity unit is individually preassembled and tested prior to final assembly, and should any one of the cavities be found to be faulty, only that one cavity need be discarded, or reworked if possible, and it is not necessary that an entirely assembled tube be discarded, as is very commonly required in present manufacturing techniques. Reworking a completely assembled tube often is a difficult and time consuming task and is to be avoided if at all possible.

As may be seen in FIG. 1, the cavities **29**, **30**, and **31** differ in size from each other; and are different in size from the cavities **26**, **27** and **28**. For example, in one typical embodiment of the present invention, the longitudinal dimensions of cavity resonators **26**, **27**, **28**, **29**, **30** and **31** are .755, .718, .664, .772, .658 and .650 inch, respectively. This is to achieve staggered tuning of the cavities so that the tube will operate over a broad range of frequencies. The sizes of the cavities are readily varied

by merely changing the thickness of the spacing members and/or the axial depths of the shoulders, such as **37** and **38**, and/or the diameters of the shoulders and the annular enclosing member **36**. The gap spacings between the reentrant nibs **40** and **41** may be varied by changing nib length, shoulder depth and/or annular enclosing member length to change either the frequency or the loaded cavity Q. Tubes constructed in accordance with the teachings of this invention lend themselves well to large volume production techniques inasmuch as spacing members of various different sizes may be maintained as stock items and tubes having various different characteristics may readily be constructed by choosing appropriate ones of the stocked spacing members so as to assemble cavities and drift tubes of the correct precalculated dimensions that will assure the desired operating characteristics in the tube.

It is virtually impossible to build a number of electron guns that have identical beam characteristics, and because the electron beam passing through a klystron cavity loads the cavity and affects its frequency of operation, it is desirable to have some type of tuning means in each cavity that will permit slight adjustment of the resonant frequency to compensate for different beam characteristics. One type of trim tuner that is compatible with a tube constructed in accordance with the teachings of this invention is illustrated in FIG. 3. As shown in this view, annular enclosing member **36** is provided with a radially-extending bore **66** into which is secured a cylinder **67** of a rigid non-yielding material. A thin flexible diaphragm **68** encloses the bottom end of cylinder **67** and forms part of the conductive boundary of reentrant cavity **26**. A rigid rod **70** is secured to the central region of flexible diaphragm **68** and extends through a clearance hole **72** in the top cover plate **73** that encloses the other end of cylinder **67**. The outer end of rod **70** is threaded and adjusting nuts **75** and **76** are threaded to rod **70** on opposite sides of cover plate **73** so as to provide means for adjusting the depth of insertion of rod **70**, and thus the position of flexible diaphragm **68** within cavity **26** so as to affect the tuning of said cavity. A notch **80** may be provided on the outer periphery of annular enclosing member **36** to assist in aligning the various parts during assembly.

It will be obvious that the various modifications may be made to the type of tube construction illustrated in FIG. 1. In one alternative embodiment, the entire tube body is comprised of an assembly of cavity units of the type illustrated in FIG. 4 wherein each cavity unit is comprised of first and second cavity end members, or spacing members **84** and **85** which are similar to the members **34** and **35** of FIG. 1 except that the cavity end members of FIG. 4 each are in abutting contact so that the members themselves provide the cavity enclosing means, thus eliminating the requirement for additional annular enclosing means such as the member **36** of FIG. 1. It has been found, however, that it is more difficult and costly to incorporate a trim tuner mechanism into the structure of this embodiment of the invention. Other obvious modifications will be apparent to those skilled in the art.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation and that changes within the purview of the appended claim may be made without departing from the true scope and spirit of the invention in its broader aspects.

What is claimed is:

A method for constructing a plural cavity electron beam tube using pretuned cavity component parts comprising

forming each cavity from first and second longitudinally-extending cavity end members, each said member being apertured longitudinally to permit the passage of an electron beam therethrough, the adjacent faces of said first and second members having respective longitudinally-extending portions in the region immediately surrounding the respective apertures, said longitudinally-extending portions being spaced to pro-

vide a gap therebetween, each said cavity having a trim tuner,

pretuning each cavity to a predetermined frequency by subjecting said first and second members to forces directed longitudinally inwardly whereby the spacing of the respective gap is permanently reduced and the resonant frequency of the respective cavity is set to a desired value,

joining the pretuned cavities to form a composite plural cavity electron beam tube, and

adjusting each said trim tuner to closely set the resonant

frequency of the respective cavity to the respective desired value.

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