

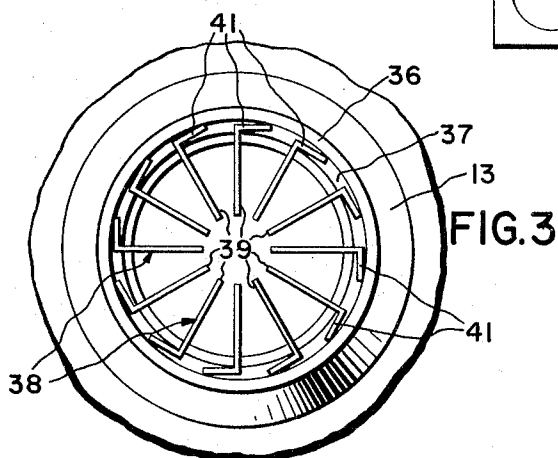
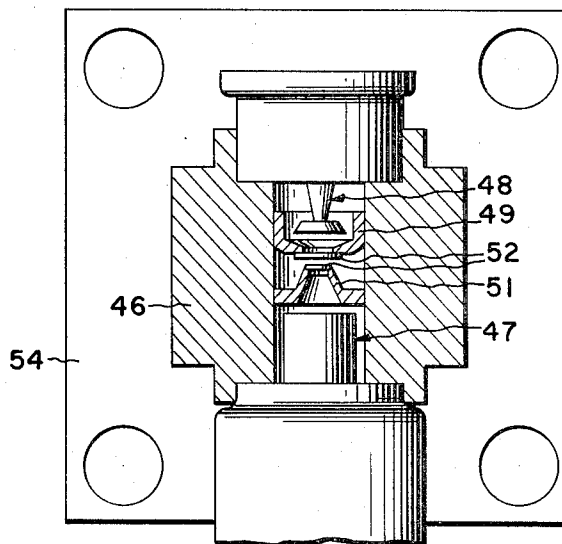
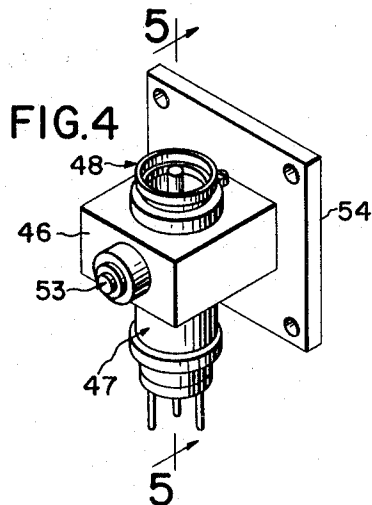
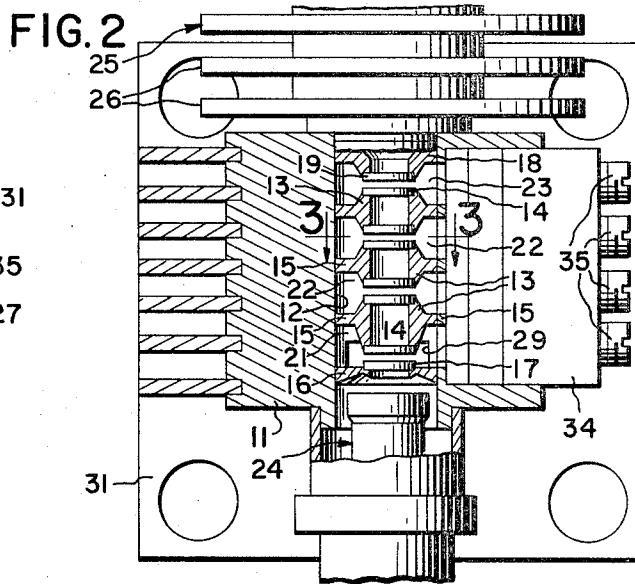
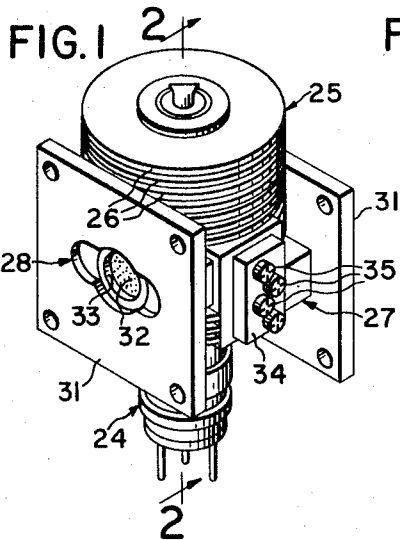
Jan. 10, 1967

A. J. FIEDOR ET AL
ELECTRON DISCHARGE DEVICE OF PARTICULAR MATERIALS FOR
STABILIZING FREQUENCY AND REDUCING MAGNETIC
FIELD PROBLEMS

3,297,905

Filed Feb. 6, 1963

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

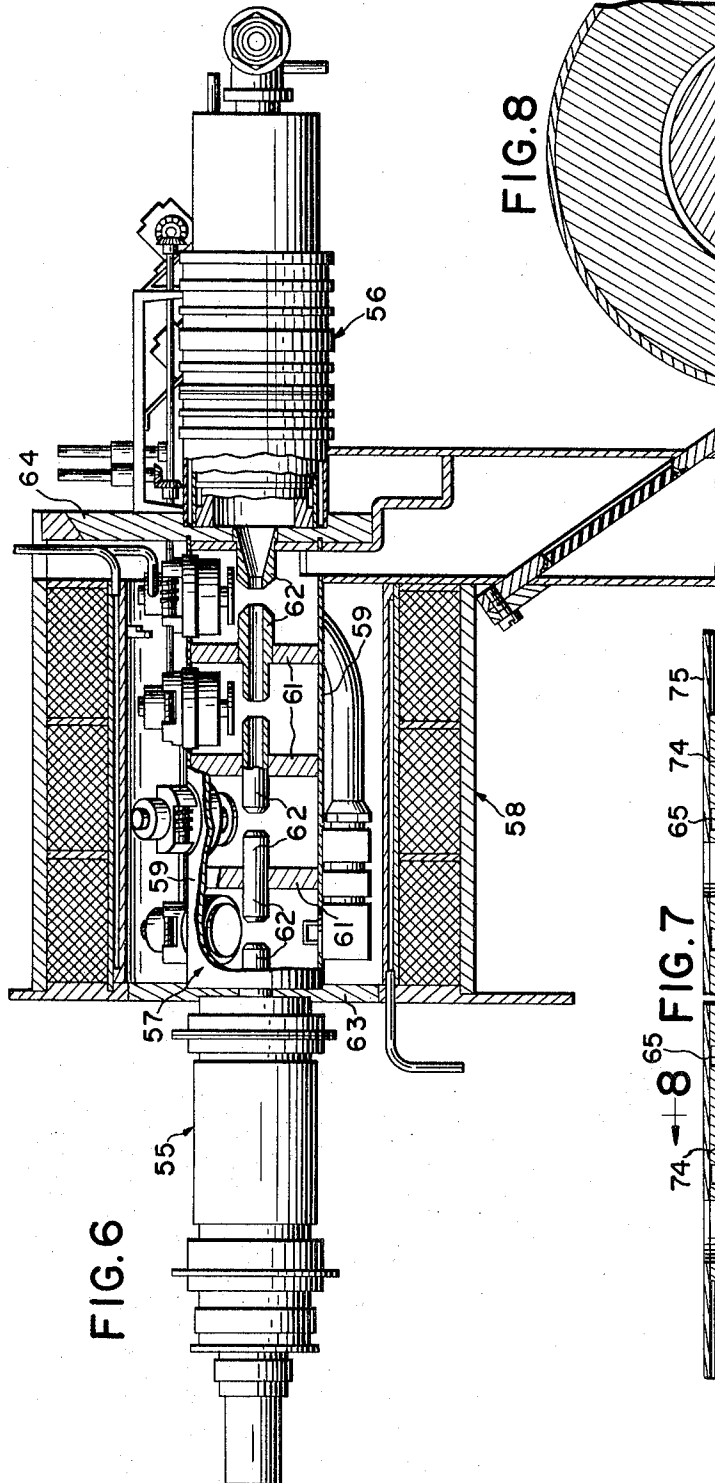


FIG. 8

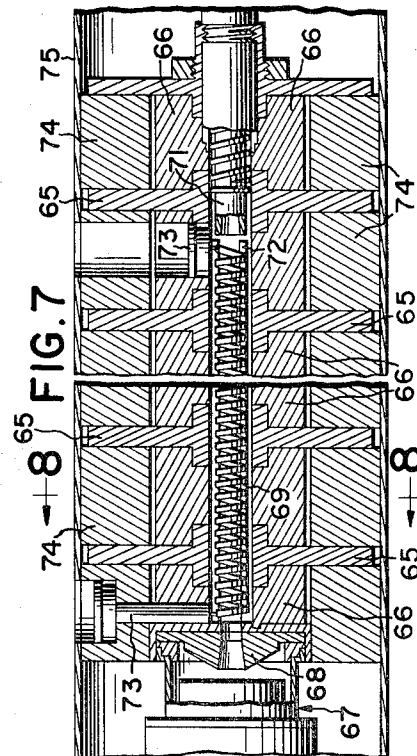
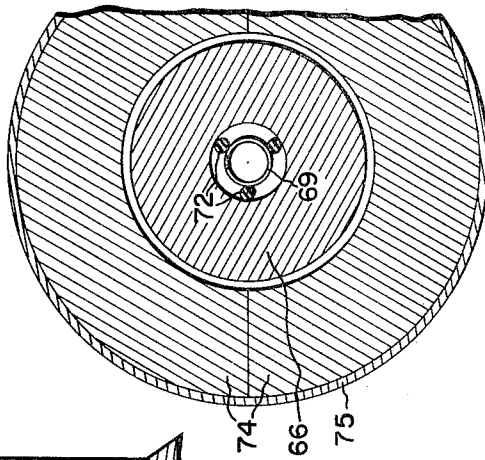


FIG. 7

FIG. 8

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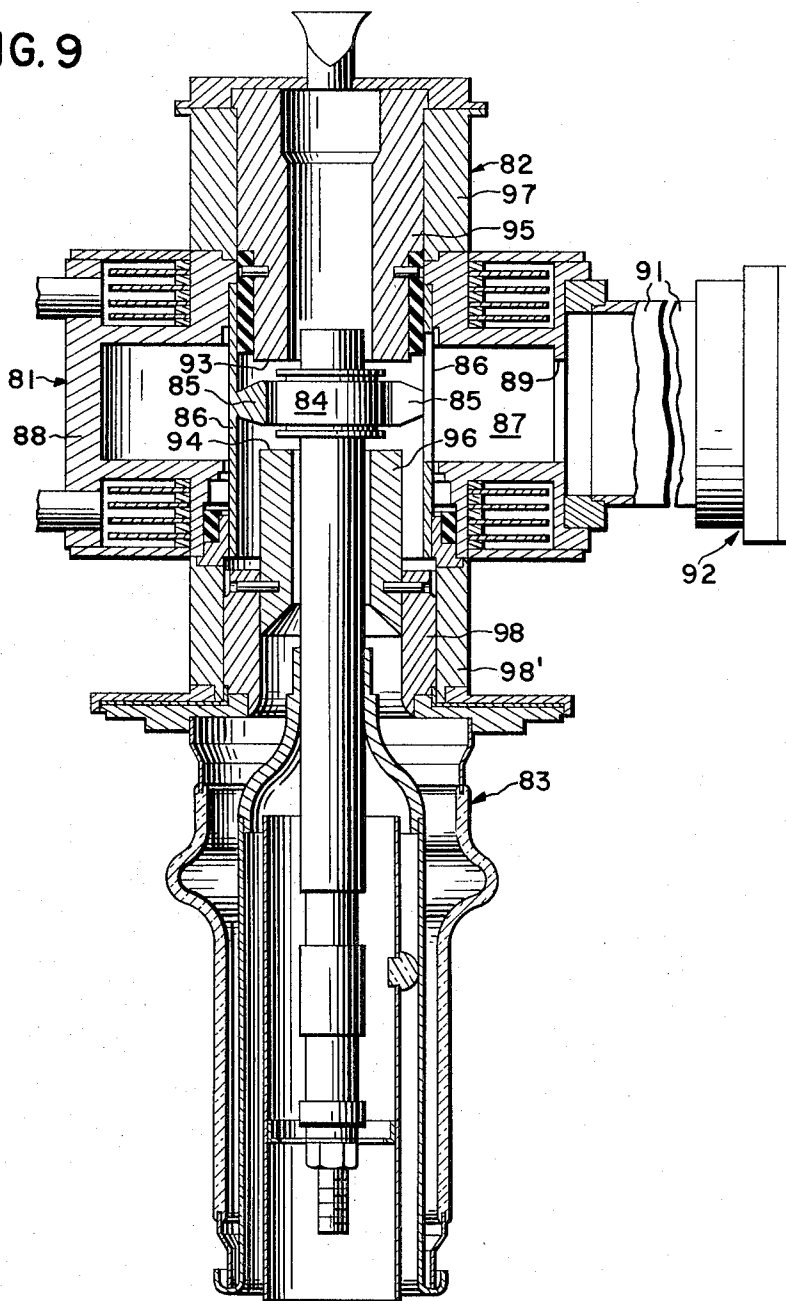
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3 Sheets-Sheet 3

FIG. 9



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3,297,905

ELECTRON DISCHARGE DEVICE OF PARTICULAR MATERIALS FOR STABILIZING FREQUENCY AND REDUCING MAGNETIC FIELD PROBLEMS

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34 Claims. (Cl. 315—3.5)

The present invention relates in general to electron discharge devices and more particularly to temperature stable electron discharge devices such as klystrons, traveling-wave tubes, magnetrons, and the like.

One of the basic criteria for the use of a particular electron discharge device or tube in an installation which must undergo changes in environmental temperature conditions, such as in an unattended radar installation exposed to atmospheric conditions or an airborne radar system or in a missile, is that the temperature coefficient (measure of frequency change with temperature change) of the device be as low as possible. The unit in which the electron discharge device is utilized may be totally useless if the temperature coefficient of the device is too high such that the frequency of the device and, therefore, of the unit will be too drastically changed with temperature.

In the past, a typical reflex klystron, for example, would change in frequency as much as 1,000 kilocycles per degree centigrade change in temperature. Such a variation in frequency could not be tolerated in an airborne installation or in a highly sensitive parametric amplifier in an exposed radar installation. With these older electron discharge devices it would be necessary to liquid cool such a tube and/or maintain the environmental conditions in which the tube was placed substantially constant.

The major cause of a high temperature coefficient for a particular tube is the existence of thermal gradients within the tube during use. The cause of thermal gradients has been the use in previous tubes of materials having low thermal conductivity. Ideally, it would be desirable to build the tube out of a material with a high thermal conductivity such as copper to avoid the undesirable thermal gradients. However, copper is not a rigid material and is characterized by a high thermal coefficient of expansion. Materials which have a high thermal coefficient of expansion are undesirable since the sizes of resonant structures of such materials will change with changes in environmental temperature conditions thereby resulting in a detuning of the device. Also, the use of a high thermal expansion type of material such as copper in conjunction with more rigid materials, such as steel bodies or magnetic materials such as iron utilized in pole pieces for such tubes, results in stresses and strains being set up in the tube due to the differences in thermal expansion between the unlike materials, often resulting in leaks at the brazed vacuum joints between the unlike materials, or misalignment of the tubes, etc.

In order to avoid thermal detuning of a tube made of material having a high thermal coefficient of expansion, electron discharge devices such as klystrons have been built of materials with low thermal coefficient of expansion and provided with a built-in temperature compensation. For example, tubes have been built utilizing a body of a material with a low thermal coefficient of expansion and drift tube headers of a material with a different thermal coefficient of expansion. For example, in U.S. Patent No. 2,815,467 to Gardner, a tube with a steel body utilizes an outwardly dished header of a material with a higher coefficient of thermal expansion,

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copper, whereby a differential expansion between the body and the header act to maintain the resonant frequency of the cavity constant. In U.S. Patent No. 2,880,357 to Snow et al., a drift tube is provided of a material with a lower coefficient of thermal expansion than the body material, steel. As the body lengthens to increase the inductance in the cavity resonator, the length of the drift tube increases but proportionately less so that the capacitance is decreased in order to maintain the frequency constant.

Tubes of the types described immediately above would still have a temperature coefficient on the order of 1,000 kilocycles per degree C. since thermal gradients would exist within the tube.

Another major disadvantage of building certain electron tubes of copper is the fact that copper is a diamagnetic material and will not shield the electron beam within the tube from stray magnetic fields. Therefore, stray magnetic fields are able to defocus the electron beam within such a tube and thereby affect both the power output and frequency stability of the device.

In the present invention certain portions of the tube structure are made to have certain desired properties of thermal conductivity, strength, magnetic susceptibility, and coefficient of thermal expansion by making these structural portions of certain selected aggregate material. For example, high thermal conductivity is a generally desired property of tube structure in order to minimize unwanted thermal gradients within the tube. Accordingly, a good thermal conductor such as copper or silver is infiltrated into a porous metallic body having another desired property such as strength alone or strength and high magnetic susceptibility. Examples of such latter body materials are tungsten and iron, respectively. The resultant aggregate will be stronger than the good thermal conducting material and have higher thermal conductivity than the stronger material. In the case of the iron aggregate, the aggregate will have a characteristic ferromagnetic susceptibility.

As used herein, an "aggregate material" is one composed of at least two different materials wherein one of the materials is infiltrated into a porous body made of the other material. High thermal conductivity is defined to mean having a thermal conductivity higher than that of tungsten. Low thermal coefficient of expansion is defined to mean having a linear coefficient of thermal expansion less than that of iron. High thermal coefficient of expansion is defined to mean having a linear coefficient thermal expansion greater than that of iron. Low magnetic susceptibility is defined as non-ferromagnetic susceptibility. High magnetic susceptibility is defined as a ferromagnetic susceptibility.

According to the present invention a highly temperature stable and rugged electron discharge device is provided by constructing a portion of the device of an aggregate material having a high thermal conductivity, a low thermal coefficient of linear expansion and low magnetic susceptibility. In a klystron, for example, this result is accomplished by constructing the cavity resonator headers and drift tubes of an aggregate material having these properties such as a material containing substantial amounts of tungsten and copper, or molybdenum and copper.

Where high magnetic susceptibility plays a part in the operation of the tube, a substantial portion of the tube may be made of an aggregate material having a high magnetic susceptibility, and a high thermal conductivity. In a klystron, for example, this second result is accomplished by constructing the body which serves to form the side walls of the cavity resonator or resonators of an aggregate material having these properties such as an aggregate containing copper and iron.

In a magnetron, for example, the first result is accomplished by constructing the vane structure of the low magnetic susceptibility, high thermal conductivity, low thermal expansion material and the second result may be accomplished by constructing the pole pieces of the high magnetic susceptibility, and high thermal conductivity material. In a periodic permanent magnetic focused traveling wave tube, for example, the pole pieces and associated spacers may form the vacuum envelope of the devices, the pole pieces being of the high magnetic susceptibility, high thermal conductivity aggregate material and the spacers being of the low magnetic susceptibility, high thermal conductivity aggregate material.

The object of the present invention is to provide improved electron discharge devices having low temperature coefficients in operation.

One feature of the present invention is the provision of an electron discharge device wherein a significant portion of the device is made of an aggregate material having a high thermal conductivity and a low thermal coefficient of linear expansion.

Another feature of the present invention is the provision of a novel electron discharge device according to the last aforementioned feature wherein the aggregate material contains substantial portions of both copper and tungsten by weight.

Another feature of the present invention is the provision of a novel electron discharge device wherein a significant portion of the device is made of an aggregate material having a high magnetic susceptibility and a high thermal conductivity whereby thermal gradients within the device are reduced.

Another feature of the present invention is the provision of a novel electron discharge device according to the last aforementioned feature wherein the aggregate material forming said significant portion contains substantial portions of both copper and iron by weight.

Other features and advantages of the present invention will become more apparent upon a perusal of the following specification taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of an electrostatically focused four-cavity klystron amplifier embodying features of the present invention,

FIG. 2 is a side view partially in section of the structure shown in FIG. 1 taken along line 2—2 in the direction of the arrows,

FIG. 3 is a cross-sectional view of a portion of the structure shown in FIG. 2 taken along line 3—3 in the direction of the arrows,

FIG. 4 is a perspective view of a reflex klystron oscillator embodying features of the present invention,

FIG. 5 is a side view partially in section of the structure shown in FIG. 4 taken along line 5—5 in the direction of the arrows,

FIG. 6 is a longitudinal cross-section view of a typical form of multicavity klystron amplifier utilizing the present invention,

FIG. 7 is a longitudinal cross-sectional view of a periodic permanent magnet focused type of traveling wave tube utilizing the present invention,

FIG. 8 is a transverse cross-section view of the tube in FIG. 7 taken along section line 8—8, and

FIG. 9 is a longitudinal cross-section view of a magnetron tube which utilizes the present invention.

Although the thermionic tubes shown in the drawing are specific forms of the klystron, magnetron and traveling wave type, it will be appreciated from what follows that while such tubes realize particularly the advantages accruing from the present invention, other tubes as well may be equally benefited.

Referring now to FIGS. 1 and 2 an electrostatically focused, multicavity klystron amplifier made in accordance with the present invention includes a central body portion 11 which is made of a unitary block of metal

having longitudinal bore therethrough. The metal of the central body portion 11 will be described in greater detail below. Hollow cylindrical drift tubes 13 having circular resonator grids 14 on the ends thereof are fixedly secured within the longitudinal bore 12 of the central body portion 11 by outwardly extending annular header members 15. The walls of the drift tube 13 are parallel to the axes of the longitudinal bore 12 and an electron beam passing therethrough.

A narrow, annular anode header 16 having a resonator grid 17 positioned in the central aperture is fixedly secured, as by brazing, in one end of the longitudinal bore 12 of the central body portion 11. Within the opposite end of the longitudinal bore 12 of the central body portion 11 is an annular header 18 with a resonator grid 19 positioned on the end of a grid tube portion projecting axially from around the aperture therethrough.

The anode header 16 and the first annular header 15 define an input cavity resonator 21 within the central body portion 11. The first, second and third annular headers 15 define two buncher cavity resonators 22; and the third annular header 15 and the annular header 18 define an output cavity resonator 23.

A beam generating assembly 24, adapted to project an electron beam axially of the central body portion 11, is vacuum sealed, as by brazing, to the central body portion 11.

A beam collector assembly 25 is fixedly secured, as by brazing, to the end of the central body portion 11 adjacent the annular header 18. The beam collector assembly 25 is provided on the exterior thereof with a plurality of annular cooling fins 26 whereby the tube can be cooled.

Identical input and output waveguide assemblies 27 and 28 are secured to the central body portion 11 and respectively communicate with the input cavity resonator 21 and the output cavity resonator 23 through milled openings 29 within the central body portion 11. The outwardly projecting end of each of the waveguide assemblies 27 and 28 is provided with a waveguide flange 31 which carries a wave permeable window 32 such as ceramic sealed therein by a window frame member 33.

A tuner block 34 is provided in one side of the central body portion 11 and provides a movable tuner diaphragm, not shown, for each cavity resonator. Each of the tuner diaphragms is movable by means of a tuning screw 35.

Referring now to FIG. 3 each of the resonator grids 14, 17 and 19 is made up of an annular grid mounting ring 36 provided with a grid support rim 37 on which a plurality of grid vanes 38 are supported. Each of the vanes 38 is made up of an elongated central body portion 39 and a base portion 41, the base portion being bent substantially 90° with respect to the central body portion and being fixedly secured, as by brazing, to grid support rim 37 with the elongated central body portion 39 projecting radially inwardly of the grid ring 36.

Referring now to FIGS. 4 and 5, there is shown a reflex klystron which embodies the present invention. This reflex klystron comprises a main body block 46 with a longitudinal bore extending therethrough. An electron gun assembly 47 and a reflector electrode assembly 48 are vacuum sealed on the body at opposite ends of the bore. The two drift tube headers or walls 49 and 51 with associated resonator grids 52 are secured within the body bore and serve to form the cavity resonator. This reflex klystron may be tuned by means of a side wall tuner 53 in well known manner, the output being coupled out from the cavity resonator through an iris opening in the body and through the waveguide flange 54. The main body and header materials of this reflex klystron will be discussed below along with the materials of the klystron of FIGS. 1 and 2.

In order to avoid undesired temperature gradients within the multicavity or reflex klystron tubes and still avoid use of materials with high coefficients of expansion, an-

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nular headers and drift tubes which are the R.F. conducting portions of the tube closest to the electron beam are made of an aggregate material having a high thermal conductivity and a low thermal coefficient of linear expansion.

For example, one typical aggregate material sold under the trademark "Elkonite" by the Mallory Metallurgical Company is an aggregate made up of substantial portions of one material, for example, either copper or silver of a high thermal conductivity and substantial portions of another material, for example, tungsten, having high strength and a low thermal coefficient of linear expansion. The aggregate material is first made by sintering the hard component, the tungsten and then melting in the lower melting point component, the copper or silver.

Aggregate materials may be made in other ways such as by dispersion hardening which may be accomplished by mechanical mixture, internal oxidization, or precipitation of more than two materials which are non-soluble and non-reactive with respect to one another.

By using an aggregate material the hot portions of the tube can be made highly thermal conductive while still very rigid. These aggregate materials may also be selected so as to have a linear coefficient of expansion approximating that of the adjacent body materials to avoid differential expansion of the tube parts which would cause detuning or strains at the vacuum joints.

By way of specific example, reference is hereby made to Table I set forth below which illustrates the use of aggregate materials for the drift tube and drift tube headers of certain reflex klystron oscillators of the type shown in FIGS. 4 and 5.

TABLE I

Tube No.	Body Material	Header and Drift Tube Material	Temperature Coefficient	Max. Beam Power Before Grid Burnout
1	Steel	Steel	-1,000 kc. per degree C	35-41.
2	do	Moly-copper laminate	Greater than ± 500 kc. per degree C.	35-41.
3	do	Elkonite: 44% copper, 56% tungsten.	Less than ± 100 kc. per degree C.	Probably 75 watts.
4	Indar: 23% copper, 77% iron.	Elkonite: 44% copper, 56% tungsten.	Less than ± 50 kc. per degree C.	Probably 100 watts.

As can be seen from Table I, tubes utilizing steel bodies and steel drift tubes and headers have an extremely high

TABLE II

Tube No.	Body Material	Drift Tube Material	Grid Ring Material and Amount of Grid Vane Raise	Frequency Shift At Beam Voltage of 1,500 Volts	Closest Spacing of Ferrite Isolator, inches
1	Copper	Copper	Nickel Raised 0.0"	-70 Megacycles	8
2	do	do	Nickel Raised .010"	-50 Megacycles	8
3	do	do	Nickel Raised .015"	-45 Megacycles	8
4	do	do	Elkonite Raised .015"	-20 Megacycles	8
5	Indar: 23% copper, 77% iron	Elkonite: 44% copper, 56% tungsten.	do	-10 Megacycles	2

temperature coefficient. In an attempt to reduce this, Tube No. 2 was built utilizing a moly-copper laminated drift tube. One such tube had a high temperature coefficient greater than ± 500 kc. per degree C. In a tube utilizing an aggregate material, specifically Elkonite of 44% copper and 56% tungsten, the temperature coefficient is typically less than ± 100 kc. per degree C.

The particular grade of Elkonite was selected as to have a high thermal conductivity and a low thermal coefficient of linear expansion. Specifically, the material was selected to have a thermal coefficient of linear expansion somewhat less than that of the body material, steel. In this manner, besides providing temperature equalization, a small temperature compensation is provided. With the header material and drift tube material of a lower thermal coefficient of expansion than the body materials, as the tube heats up the cavity enlarges due to the effect of the

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body material thereby increasing inductance. The drift tube material enlarges but to a lesser extent thereby increasing the interaction gap space to decrease the capacitance thereof and thereby maintain the cavity resonator frequency constant.

The central body portion 11 of the klystron amplifier tube of FIGS. 1 and 2 and the central body portion 46 of the reflex klystron of FIGS. 4 and 5 is made of an aggregate material having a high thermal conductivity and a high magnetic susceptibility. With this body material the electron beam therein is shielded from stray magnetic fields which would act to defocus the beam and both reduce the power output and change the tube operating frequency. A specific central body aggregate material is Indar which is a trade name for a material manufactured by the Indar Corporation. The specific type of Indar utilized in a specific tube was one containing 23% of copper and 77% iron.

As is evident from Table II the Indar body magnetically shielded the tube from stray magnetic fields. Without the Indar body a magnetic attenuator or ferrite isolator used in a system with the tube had to be positioned at least 8" from the tube whereas when utilizing an Indar body the ferrite isolator could be placed within 2" of the tube and actually bolted to a flange of the tube.

Another feature of the present invention is the provision of a grid ring 36 made out of an aggregate material such as Elkonite. Grid rings of such material provide better temperature equalization by rapidly conducting heat from the grid and grid vanes thereby avoiding grid burn-out and frequency shift due to increased beam current.

Specific examples of features of this embodiment of the present invention are set forth in Table II below.

As can be seen from the above table the use of an Elkonite grid ring considerably reduced the frequency shift for increased beam voltage.

In a magnetically focused type of electron tube device, as, for example, a magnetic focused multicavity klystron tube of the type shown in FIG. 6, the utilization of an aggregate material, for example copper-iron, with a high thermal conductivity characteristic and yet a good magnetic susceptibility can be appreciated. This klystron tube is similar to one shown and described in U.S. Patent 2,963,616 issued December 6, 1962, to R. B. Nelson et al. and will not be described in detail herein except to the extent necessary to indicate the utilization of the present invention therein. This klystron tube, in general, includes a cathode structure 55, an electron beam collector structure 56, the multicavity R.F. interaction structure 57, and the electron focusing magnet structure 58.

To enhance the thermal conductivity of the tube a pair of pole pieces 63 and 64, which form a part of the electron beam focusing magnetic field structure 58, are made of an aggregate material having a high thermal conductivity and a high magnetic susceptibility, for example, an aggregate material which is 20-30% copper and 80-70% iron.

To achieve improved thermal conductivity with this multicavity klystron, the main body wall 59, the cavity end walls or headers 61, and the drift tubes 62 are made of an aggregate material having a high thermal conductivity characteristic and a low magnetic susceptibility and a coefficient of thermal expansion approximating the thermal coefficient of expansion of the pole pieces 63 and 64. For example, an aggregate material of 70% copper and 30% tungsten is suitable.

These latter two forms of aggregate material are, of course, advantageously employed in other forms of klystrons such as in, for example, the permanent magnet focused type, an example of which is shown in U.S. Patent 2,915,670, issued December 1, 1959, to Louis T. Zitelli.

As an alternative embodiment of the present invention the pair of magnetic pole pieces 63 and 64, forming a part of the beam trajectory confining structure, are made of iron. In this case the main body wall 59, cavity end walls 61, and the drift tubes 62 are made of an aggregate material having a high thermal conductivity, high strength, a low magnetic susceptibility, and a coefficient of thermal expansion approximating the thermal coefficient of expansion of the pole pieces 63 and 64. A suitable aggregate for this purpose is Elkonite having 65% copper and 35% tungsten.

The present invention also finds particular utility in a traveling wave tube of the periodic permanent magnet focusing type wherein the focusing magnetic field comprises successive periodically reversed axial magnetic fields as is now well known in this field. In the embodiment shown in FIGS. 7 and 8, a plurality of spaced-apart magnet pole pieces 65 and a plurality of spacers 66 inserted between the pole pieces are made of materials suitable to be brazed together to form a vacuum tight envelope for the traveling wave tube. The pole pieces 65 and the spacers 66 must be of different materials since the pole pieces must have high magnetic susceptibility and the spacers have low magnetic susceptibility but it is desirable that both spacers and pole pieces have high thermal conductivity and yet be compatible with regard to their coefficients of thermal expansion to avoid leaks in the vacuum joints.

The traveling wave tube shown in FIGS. 7 and 8 includes a cathode assembly 67, anode 68, the slow wave helix 69, and the electron beam collector assembly 71. The main vacuum envelope of this traveling wave tube includes the plurality of annular pole pieces 65 and the annular spacers 66 which are brazed to the pole pieces 65. The helix 69 is supported within the longitudinal bore formed in the axial center of the pole pieces 65 and the spacers 66 by sapphire rods 72. Suitable input and output coupling means 73 are vacuum sealed within the pole piece spacer assembly. The magnets 74 which form the periodic magnetic fields are formed of two C-shaped halves which clamp around the spacers and adjacent the pole pieces, these magnets being so positioned as to form the periodically reversed magnetic fields extending between the pole pieces 65 axially of the structure. A hollow cylindrical sleeve 75 is secured around the outer periphery of the permanent magnets 74 to hold the assembly in place.

In this embodiment, the pole pieces 65 are made of an aggregate material having a high thermal conductivity and a high magnetic susceptibility, for example, an aggregate material having a substantial portion of iron, for example, 23%-30% copper and 77%-70% iron. The annular spacers 66 are made of an aggregate material

having a high thermal conductivity and a low magnetic susceptibility, for example, a copper-tungsten aggregate such 49% copper and 51% tungsten. The coefficient of thermal expansion of these two aggregate materials is compatible and no serious problems are encountered with leaks, misalignment, etc., due to thermal expansion differences between the pole pieces and the spacers during operation.

The use of this invention in a cross-field device or magnetron is exemplified in FIG. 9 which discloses, in longitudinal cross-section, a typical form of magnetron of the type more clearly shown and described in U.S. patent application Serial No. 105,715 entitled, "Magnetron," filed April 26, 1961, in the name of Jerome Drexler et al. This specific form of magnetron is sold as model SFD-303 by the S-F-D Laboratories of Union, New Jersey. The main body assembly of this magnetron is designated by reference numeral 81 to which there is suitably brazed the anode assembly 82 and the cathode assembly 83 including the cylindrical cathode emitter 84. The magnetron interaction region is defined by the cylindrical space between the outer periphery of the cylindrical cathode emitter 84 and the inner tips of a circular array of radially inwardly directed anode vanes 85 or wave supporting structure which are carried at their outer peripheries from the inside surface of a cylindrical anode wall 86. As is well known in this art, the spaces between adjacent vanes within the interior of the cylindrical anode wall 86 define the plurality of inner cavity resonators which interact with the electron beam or stream of this device. The outer cavity resonator 87 is formed in the main body block 88 and is coupled to the inner resonators defined by the vanes 85 and walls 86 through coupling holes in the wall 86 in well known manner. The output energy is extracted from the magnetron via output coupling slot 89, waveguide 91, and vacuum sealed window structure 92.

This known form of magnetron incorporates a magnetic circuit or structure which provides a tubular shaped magnetic field extending between the inner ends 93 and 94 of the two cylindrical pole pieces 95 and 96, these pole pieces being coupled to a C-shaped permanent magnet (not shown) via cylindrical magnetic members 97 and 98 and 98'.

In an improved form of this magnetron made in accordance with the present invention, the vanes 85, wall section 86, and/or external cavity wall 88 may be made of an aggregate material having a high thermal conductivity, and low magnetic susceptibility such as, for example, copper-tungsten or silver tungsten. Thus the high conductivity will insure rapid heat dissipation and the low thermal expansion will insure small changes in size with temperature changes.

In addition, the magnetic members 95, 96, 97, 98 and 98' may be made of an aggregate material having a high thermal conductivity and a high magnetic susceptibility such as, for example, an aggregate material with substantial portions of copper and iron.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An electron discharge device comprising:

- (a) means for producing an electron beam, and
- (b) conductor means adjacent said electron beam producing means for conducting radio frequency wave energy,

(1) said conductor means being made of an aggregate material comprising a porous metallic structure made of a material having a thermal

coefficient of linear expansion less than that of iron with the pores of said porous structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten.

2. The electron discharge device of claim 1 wherein said aggregate material contains substantial portions of copper by weight.

3. The electron discharge device of claim 1 wherein said aggregate material contains between 30 and 70% copper by weight.

4. The electron discharge device of claim 1 wherein said aggregate material contains substantial portions of copper and tungsten by weight.

5. The electron discharge device of claim 4 wherein said aggregate material contains between 30 and 70% copper by weight and 70 and 30% tungsten by weight.

6. A resonator structure comprising:

(a) a cavity resonator adapted to pass an electron beam therethrough,

(b) means defining cavity end walls for conducting electromagnetic waves, and

(c) an interaction gap defined by a pair of drift tubes projecting from mutually opposing cavity end walls,

(d) said drift tubes and said opposing cavity end walls made of an aggregate material comprising a porous metallic structure of a first metal having a thermal coefficient of linear expansion less than that of iron with the pores of said porous metallic structure infiltrated with a second metal having a thermal conductivity greater than that of tungsten.

7. The resonator structure of claim 6 wherein said aggregate material contains substantial portions of copper by weight.

8. The resonator structure of claim 6 wherein said aggregate material contains substantial portions of copper and tungsten by weight.

9. A high frequency tube apparatus including:

(a) a main body,

(b) means for producing an electron beam within said body,

(c) said body having at least one cavity resonator formed therein in the beam path for electromagnetic interaction with the electron beam,

(d) said main body forming the side walls of said cavity resonator,

(e) header members forming the end walls of said cavity resonator and adapted to pass an electron beam therethrough,

(f) said header members made of an aggregate material comprising a porous metallic structure made of a first metal having a thermal coefficient of linear expansion less than that of iron with the pores of said metallic body infiltrated with a second metal having a thermal conductivity greater than that of tungsten.

10. The tube apparatus of claim 9 wherein said aggregate material contains substantial portions of copper by weight.

11. The tube apparatus of claim 7 wherein said aggregate material contains substantial portions of copper and tungsten by weight.

12. A high frequency tube apparatus including:

(a) a main body,

(b) means for producing an electron beam within said main body to produce radio frequency energy,

(c) conductor means adjacent said electron beam producing means for conducting radio frequency wave energy,

(d) said main body being made of an aggregate material comprising a porous metallic structure made of a material having a ferromagnetic susceptibility with the pores of said metallic structure infiltrated with a second metal having a thermal conductivity greater than that of tungsten.

13. The tube apparatus of claim 12 wherein said aggregate material contains substantial portions of copper by weight.

14. The tube apparatus of claim 12 wherein said aggregate material contains substantial portions of copper and iron by weight.

15. The tube apparatus according to claim 12 wherein said aggregate material contains between 15 and 40% copper by weight and between 85 and 60% iron by weight.

16. A high frequency tube apparatus including:

(a) a main body,

(b) means for producing an electron beam within said body,

(c) said body having at least one cavity resonator formed therein in the beam path for electromagnetic interaction with the electron beam,

(d) said means body forming the side walls of said cavity resonator and made of an aggregate material comprising a porous metallic structure made of a material having ferromagnetic susceptibility with the pores of said metallic structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten,

(e) header members forming the end walls of said cavity resonator and adapted to pass the electron beam therethrough for electromagnetic interaction at a gap therebetween,

(f) said header members made of an aggregate material comprising a porous metallic structure of a metal having a thermal coefficient of expansion less than that of iron with the pores of said porous structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten.

17. The high frequency tube apparatus of claim 16 wherein,

(a) said main body is made of an aggregate material containing substantial portions of copper and iron by weight and

(b) said header members are made of an aggregate material containing substantial portions of copper and tungsten by weight.

18. A grid structure comprising:

(a) an annular grid mounting ring provided with a grid support rim,

(b) a plurality of grid vanes supported on said grid support rim.

(1) each of said vanes provided with an elongated central body portion and a base portion at the end of said central body portion, and

(2) said base portion of each of said vanes secured to said grid support rim,

(c) and said mounting ring being made of an aggregate material comprising a porous metallic structure made of a metal having a nonferromagnetic susceptibility with the pores of said metallic structure infiltrated with second metal having a thermal conductivity greater than that of tungsten.

19. The grid structure of claim 18 wherein said mounting ring is made of substantial portions of copper.

20. The apparatus according to claim 19 wherein said aggregate mounting ring contains substantial proportions of a metal selected from the group consisting of tungsten and molybdenum.

21. A high frequency tube apparatus of the magnetic focus type comprising in combination:

(a) a main body forming a portion of the vacuum envelope of said tube apparatus,

(b) means for producing an electron beam in said body,

(c) said body having at least one cavity resonator formed therein in the beam path for electromagnetic interaction with the electron beam passable there-through,

- (d) header members forming the end walls of said cavity resonator and adapted to pass the electron beam therethrough for electromagnetic interaction at a gap within said cavity resonator,
- (e) magnetic pole members forming another portion of said body and extending on either side of said cavity resonator for operating with external magnetic means to focus the electron beam within said cavity resonator, said pole pieces being of an aggregate material comprising a porous metallic structure made of a ferromagnetic susceptibility with the pores of said metallic structure infiltrated with a second metal having a thermal conductivity greater than that of tungsten,
- (f) said main body forming the side walls of said cavity resonator, said main body and said header members being made of an aggregate material comprising a porous metallic structure made of a material having a nonferromagnetic susceptibility with the pores of said metallic structure infiltrated with a second metal having a thermal conductivity greater than that of tungsten.
22. A high frequency tube apparatus as claimed in claim 21 wherein the aggregate material of said body and header material has a thermal coefficient of expansion within 30% of the thermal coefficient of expansion of said pole members.
23. Tube apparatus of claim 21 wherein said aggregate material of the body and header members contains substantial portions of copper and tungsten by weight.
24. A high frequency tube apparatus according to claim 21 wherein the aggregate material of said pole comprises a substantial portion of copper and iron.
25. An electron beam tube of the traveling wave tube type comprising means for producing an electron beam therein,
- (a) a slow wave structure for interaction with said electron beam,
- (b) a collector for collecting said electron beam,
- (c) said electron tube including a magnetic focusing structure including a plurality of annular pole pieces positioned along the length of the electron beam and a plurality of spacer members located between the pole piece members and serving to space said pole pieces one from another,
- (d) and said pole piece members being of an aggregate material comprising a porous metallic structure made of a metal having a ferromagnetic susceptibility with the pores of said metallic structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten.
26. The traveling wave tube apparatus as claimed in claim 25 wherein said spacer members are made of an aggregate material comprising a porous metallic structure made of a nonferromagnetic susceptibility metal with the pores of said metallic structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten.
27. The apparatus according to claim 26 wherein said spacer members have a thermal coefficient of expansion within 30% of the thermal coefficient of expansion of said pole piece members.
28. The traveling wave tube apparatus as claimed in claim 26 wherein the aggregate material of said pole pieces comprises substantial portions of copper and iron and wherein said aggregate material of said spacers comprises substantial portions of copper and tungsten.

29. High frequency tube apparatus of the crossed field type comprising:
- (a) a main body forming a portion of a vacuum envelope of said tube apparatus,
- (b) means for producing a stream of electrons in said main body,
- (c) said main body having a wave supporting structure therein in wave energy exchanging relationship with said stream of electrons,
- (d) magnetic structure formed within said body for directing a magnetic field having a substantial component thereof normal to the mean direction of travel of the electron stream,
- (e) said main body being made of an aggregate material comprising a porous metallic structure made of a nonferromagnetic material with the pores of said metallic structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten,
- (f) and said magnetic structure being made of an aggregate material comprising a porous metallic structure made of a material having a ferromagnetic susceptibility with the pores of said structure being infiltrated with a second metal having a thermal conductivity greater than that of tungsten.
30. The apparatus according to claim 29 wherein said aggregate material of said main body and said magnetic structure contains a substantial proportion of copper by weight.
31. The apparatus according to claim 29 wherein said aggregate material of said main body and said wave supporting structure contains a substantial proportion of copper and tungsten by weight.
32. The apparatus according to claim 29 wherein said material of said magnetic structure contains a substantial proportion by weight of copper and iron.
33. A high frequency tube apparatus employing a magnetically confined electron stream comprising:
- (a) a main body forming a portion of a vacuum envelope of said tube apparatus,
- (b) means for producing a stream of electrons in said main body,
- (c) said main body having a wave supporting structure therein in wave energy exchanging relationship with said stream of electrons,
- (d) magnetic structure formed within said body for directing a magnetic field into the stream of electrons for confining the stream of electrons to a desired trajectory,
- (e) said magnetic structure being made of iron,
- (f) and said main body being made of an aggregate material comprising a porous metallic structure made of a metal having a nonferromagnetic susceptibility with the pores of said metallic structure infiltrated with a second metal having a thermal conductivity greater than that of tungsten.
34. The apparatus according to claim 33 wherein said aggregate material of said body has a thermal coefficient of expansion within 30% of the thermal coefficient of expansion of said iron magnetic structure.

References Cited by the Examiner

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