Jan. 11, 1966 D. J. HODGES 3,229,152

MAGNETRON HAVING EVACUATED DISCHARGE SUBASSEMBLY UNITED WITH UNEVACUATED MAGNETIC AND RESONANT CAVITY STRUCTURE

Filed Oct. 19, 1961 2 Sheets-Sheet 1

FIG. 1.

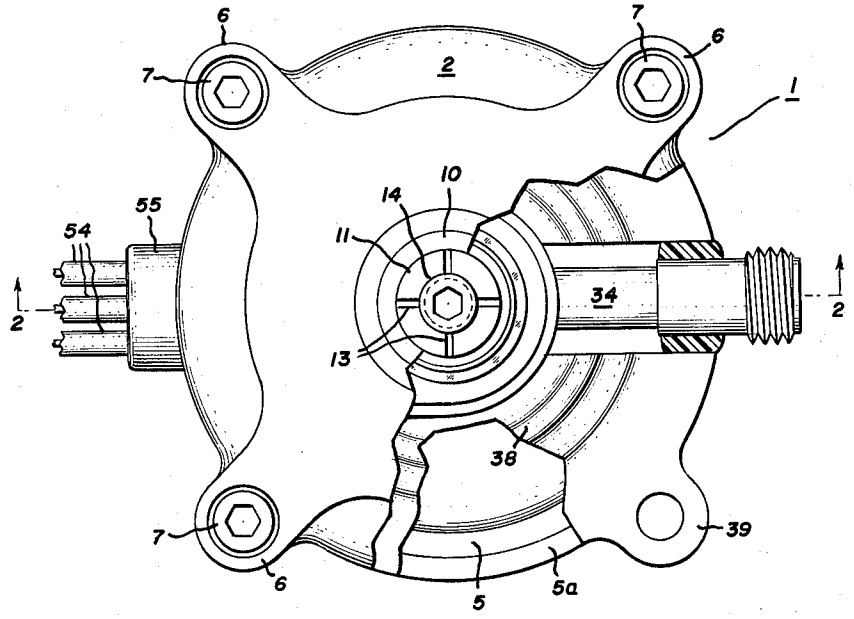


FIG. 2.

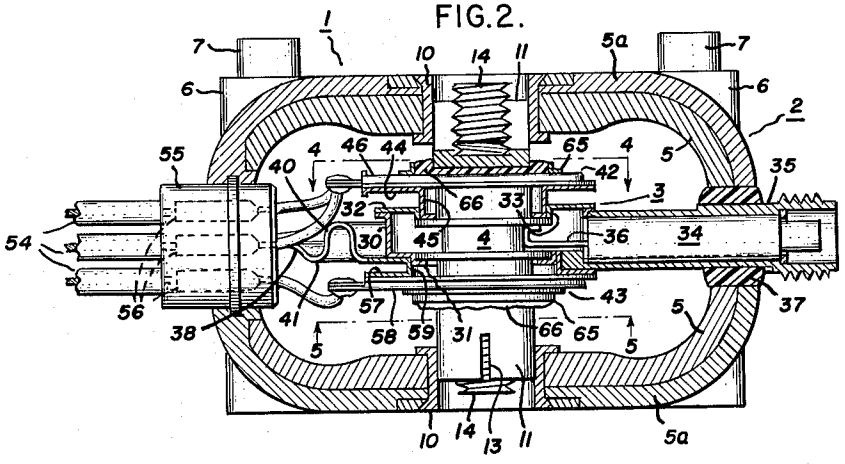
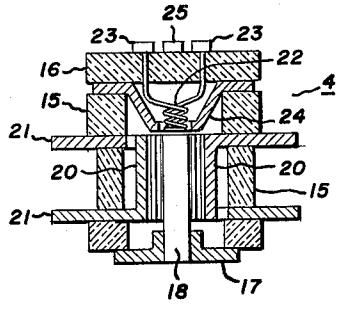


FIG. 2A.



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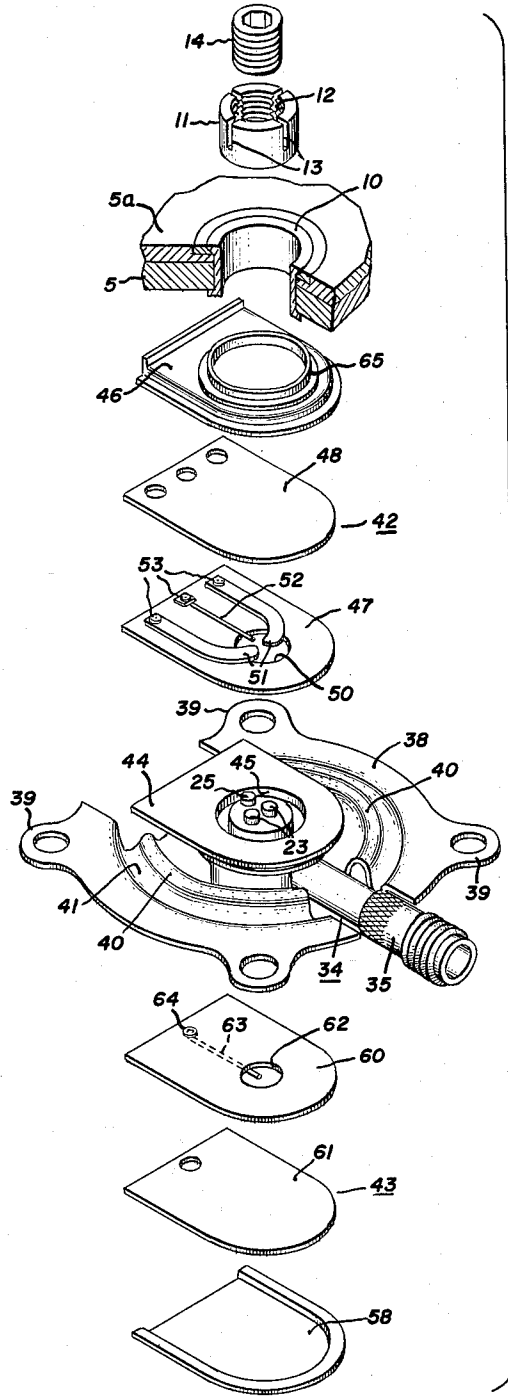


FIG.3.

FIG.4.

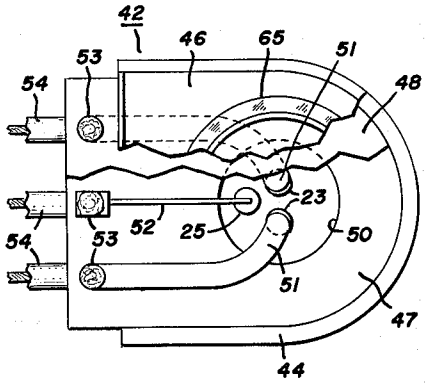
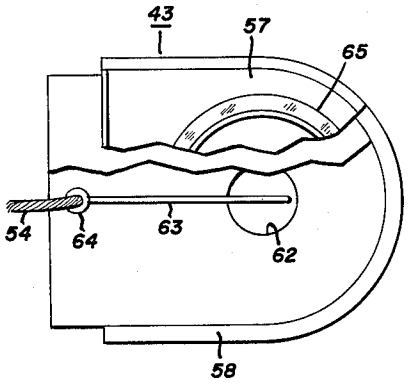


FIG.5.



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Patented Jan. 11, 1966

3,229,152

MAGNETRON HAVING EVACUATED DISCHARGE SUBASSEMBLY UNITED WITH UNEVACUATED MAGNETIC AND RESONANT CAVITY STRUCTURE

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Filed Oct. 19, 1961, Ser. No. 146,162
19 Claims. (Cl. 315—39.71)

My invention relates to radio frequency apparatus and pertains more particularly to improved voltage tunable magnetron packages and improved means and method for manufacturing such packages.

A voltage tunable magnetron package generally comprises a unitary structure including an R.F. cavity circuit having an R.F. output and a voltage tunable magnetron securely mounted in the circuit, D.C. circuit means for applying appropriate operating potentials to the electrodes of the voltage tunable magnetron, and a magnet assembly. The magnet assembly generally includes a permanent magnet having closely spaced opposed pole pieces and means for mounting the voltage tunable magnetron and circuit means in a predetermined adjusted position in which a magnetic field between the opposed pole pieces extends generally coaxially through the magnetron.

In the design and manufacture of a voltage tunable magnetron package it is often desirable to obtain a structure which is adapted for long-life operation under various severe environmental conditions, such as shock, vibration and temperature extremes. Additionally, it is desirable to obtain such operation without degrading radio frequency performance. Further, it is desirable to obtain a structure which meets the requirements of withstanding severe environmental conditions and providing high R.F. performance and yet is relatively simple structurally. Still further, it is desirable to provide structure and manufacturing methods whereby voltage tunable magnetron packages can be manufactured in a manner which enables relatively easily adjustable positioning of the magnetron relative to the magnetic field between the opposed pole pieces of the magnet assembly and can be relatively easily and quickly manufactured in quantities with assurance of uniform optimum performance of the packages so manufactured. It is desirable also to provide a voltage tunable magnetron package adapted for high heat transfer from the magnetron contained therein to the magnet assembly which serves as a suitable heat sink, thereby to minimize performance degradation due to overheating of the magnetron. In some voltage tunable magnetron package designs it is also desirable to provide for mounting of the magnetron and circuit therefor in thermally conductive but electrically insulated relation to the magnet assembly.

My invention contemplates voltage tunable magnetron package structures and a method of manufacturing same adapted for satisfying all of the above-discussed desiderata and, accordingly, a primary object of my invention is to provide a new and improved voltage tunable magnetron package structure including new and improved means adapted for facilitating the adjustable positioning of a voltage tunable magnetron and R.F. circuit therefor in a magnet assembly and for securing same in an adjusted position.

Another object of my invention is to provide a new and improved voltage tunable magnetron package structure including new and improved means for mounting the magnetron and circuitry therefor in the magnet assembly in a manner to resist shock and vibration, thereby to avoid degradation of R.F. performance and insure desired long operating life of the package.

Another object of my invention is to provide a new and improved method for manufacturing a voltage tunable magnetron package.

Another object of my invention is to provide new and improved means and method for assembling a preadjusted voltage tunable magnetron package, whereby the package is adapted for optimum R.F. operation.

Another object of my invention is to provide new and improved means for mounting a voltage tunable magnetron and circuitry therefor in a so-called "bowl-type" magnet assembly.

Another object of my invention is to provide a voltage tunable magnetron package including a bowl-type magnet assembly and new and improved means and method for enabling preadjustable positioning of a magnetron circuit therefor in the magnet and for rigidly affixing same in a preadjusted position.

Another object of my invention is to provide a voltage tunable magnetron package including a bowl-type magnet assembly and new and improved means for mounting a voltage tunable magnetron and circuit therefor in a high heat transferring relation to the magnet.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterizes my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide a unitary package assembly including a bowl-type magnet subassembly comprising a pair of opposed dish-shaped permanent magnet segments secured together to define an enclosed space. The magnet segments include coaxial apertures for carrying removable coaxial pole pieces and means whereby the pole pieces can be locked in adjusted positions in the apertures. Each of the magnet segments is enclosed in a generally dish-shaped jacket of low heat retentivity material and formed to include bored bosses for receiving bolts for securing the segmented portions of the assembly together. Contained in the space defined by the magnet segments is a circuit subassembly including an R.F. circuit having a coaxial output and a voltage tunable magnetron mounted therein. The R.F. circuit construction consists of an apertured cup-like member and a washer-like cover which, when joined at the rims provide highly satisfactory R.F. properties and rigid retention of the magnetron therein. The circuit subassembly includes a heat-conductive flexible diaphragm which has its edges secured between the opposed edges of the dish-shaped magnet segments and supports the R.F. circuit in the enclosed space defined by the magnet segments with the magnetron generally coaxially aligned with the magnet pole pieces. D.C. circuitry including D.C. contact structures are included in the circuit subassembly and are positioned between the opposed ends of the magnetron and adjacent inner ends of the magnet pole pieces and are rigidly secured to the R.F. circuit. These contact structures provide for applying appropriate operating potentials on the electrodes of the voltage tunable magnetron. The coaxial R.F. output and leads to the D.C. contacts extend in electrically-insulated relation to each other and the bowl-type magnet subassembly through diametrically opposed openings in the wall thereof. The opposed surfaces of the D.C. contact structures each carry an annular retainer element filled with a quantity of thermally conductive bonding material which extends between the circuit structure and the inner ends of the pole pieces for rigidly securing the magnetron circuit structure in a desired position in the magnet subassembly. The bonding material can, if desired, be either electrically conductive or electrically insulative in addition to being thermally conductive, depending upon whether it is desired to insu-

late or electrically connect the magnetron subassembly and contained circuit structure. If desired, the heat-conductive diaphragm which partially supports the magnetron circuit in the magnet sub-assembly can be eliminated, in which case the bonding material can be relied upon as the sole means for rigidly supporting the magnetron and its associated circuitry in the magnet subassembly. In this type of structure it is sometimes desirable that the bonding material be thermally conductive but electrically insulative.

In practicing the method aspect of my invention, I construct the magnet and circuit subassemblies separately, assemble the package with the circuit subassembly in the magnet subassembly, lock the pole pieces in place, adjustably position the circuit subassembly in the magnet subassembly by manipulating the R.F. output while operating the magnetron, holding the subassemblies in this desired adjusted relation, removing the pole pieces, introducing the bonding material into the retainer members on the D.C. contact structures and about the R.F. output, reinserting and locking the pole pieces in place in the magnet subassembly and setting the bonding material in order to join rigidly the circuit subassembly to the pole pieces and the R.F. output to the magnet subassembly.

For a better understanding of my invention, reference may be had to the accompanying drawing in which:

FIGURE 1 is a fragmentary plan view of an embodiment of my invention;

FIGURE 2 is a sectional view taken along the line 2—2 in FIGURE 1 and looking in the direction of the arrows;

FIGURE 2A is a sectional view of the voltage tunable magnetron illustrated in position in FIGURE 2;

FIGURE 3 is an exploded perspective view illustrating certain features of my invention;

FIGURE 4 is a fragmentary plan view of the upper D.C. contact structure taken along the line 4—4 in FIGURE 2 and looking in the direction of the arrows; and

FIGURE 5 is a fragmentary plan view of the lower D.C. contact structure taken along the line 5—5 in FIGURE 2 and looking in the direction of the arrows.

Referring to FIGURES 1 and 2, there is shown a voltage tunable magnetron package generally designated **1** and including a bowl-type magnet subassembly **2** containing a circuit subassembly **3** in which is mounted a voltage tunable magnetron **4**.

The magnet subassembly **2** comprises an opposed pair of dish-shaped permanent magnet segments **5** each securely fitted in a die-cast non-magnetic mount or casing **5***a* which is also generally dish-shaped. The mounts or casings **5***a* can be advantageously formed of aluminum or any other low heat retentivity material and with bosses **6** which are centrally bored for the passage therethrough of bolts **7** for securing the elements comprising the magnet subassembly together in the manner illustrated and to define an enclosed space therein. Additionally, the magnet segments **5** and casings **5***a* are formed to include coaxial apertures into which are suitably tightly fitted tubular insert elements **10**. Slidably and removably positioned in each insert element **10** is a cylindrical pole piece **11** formed preferably of a high permeable magnetic material such as soft iron.

As perhaps better seen in FIGURE 3, each pole piece **11** includes a tapped, or internally threaded, central bore **12**, which bottoms short of the inner end thereof, and a plurality of circumferentially spaced radial slots **13** which extend from the bored bottom to the outer end. Threaded in the bores are slightly oversized machine screws **14** which when turned into the pole pieces cause them to expand for becoming thusly locked in the positions illustrated in FIGURE 2, in which positions the pole pieces serve to concentrate a magnetic field therebetween and which extends generally coaxially through the voltage tunable magnetron **4**.

The pole pieces **11** are adapted for being removable in the above-described manner in order to facilitate the adjustable positioning of the voltage tunable magnetron relative to the magnet field between the pole pieces in the manner to be desecribed in detail hereinafter. Additionally, the described locking means enables the pole pieces to be adjustably positioned relative to the circuit subassembly.

The voltage tunable magnetron **4** can be of the type disclosed and claimed in U.S. Patent No. 2,930,933 of G. J. Griffin, Jr. et al., issued March 29, 1960 and assigned to the same assignee as the present invention. Such a tube is illustrated in section in FIGURE 2*a* to bring out the relative location of electrode contacts thereby to facilitate the description and understanding of the R.F. and D.C. circuit elements incorporated in my presently disclosed invention. Briefly, and as illustrated in FIGURE 2*a*, the magnetron **4** is constructed to include stacked alternate ceramic and metal elements. The ceramic elements generally include a plurality of cylindrical ceramic wall sections **15** and an apertured disk-like ceramic end cap **16**. The metal members are suitably brazed to or between opposed surfaces of the ceramic elements to complete a hermetically sealed evacuated envelope and include a metal end cap **17** carrying a cylindrical non-emissive cathode **18** extending centrally in a cylindrical space defined by a plurality of anode segments generally designated **20**. The anode segments **20** are arranged in a pair of interdigital sets, with each segment being carried by a washer-like anode contact ring **21**. The rings **21** are sealed between a pair of ceramic cylinders **15** and are thus mutually insulated. A filamentary emitter **22** is suitably mounted on the ceramic end cap **16** with leads sealed therethrough and connected to a pair of button-like contact members **23** bonded to the outer surface of the ceramic end cap. A frusto-conical control electrode **24** is sealed between one of the ceramic insulators **15** and the ceramic end cap **16** and is positioned about the emitter **22**. By means of a lead not shown and which extends also in a sealed manner through the ceramic end cap **16**, an electrical connection is made between the control electrode **24** and a first button like contact member **25** bonded to the outer surface of the ceramic end cap.

In the presently disclosed structure the magnetron **4** is adapted for operating while axially aligned with the magnetic field extending between the pole pieces **11** of the above-described magnet assembly and when mounted in the R.F. circuit **3**. Additionally, the magnetron requires for operation the application of suitable D.C. potentials on the various electrodes supplied through the metal end cap **17** and the contact buttons **23** and **25**. The R.F. and D.C. circuits of the present structure are now to be described in detail. The R.F. circuit designated **3** in FIGURE 2 is of the so-called "pill-box" type and is so characterized because of its generally simple and easily manufactured flat round box-like construction. Specifically, the R.F. circuit comprises a generally cup-like conductive member **30** having a bottom which is apertured and includes an annular shoulder or stepped section **31** which receives and makes annular electrical contact with one of the anode rings **21** of the magnetron. The top of the R.F. circuit comprises a washer-like conductive member **32** which is welded to the rim of the member **30** and includes a dependent inner rim **33** which makes annular electrical contact with the other anode ring **21** of the magnetron. The member **30** has an outer diameter substantially greater than the outer diameters of the anode rings **21** and thus is provided an annular resonant cavity disposed about the magnetron. The described R.F. circuit structure, it will be noted, involves only two relatively easily and inexpensively formed sheet metal elements and is adapted for holding a voltage tunable magnetron securely captured therein through the simple agency of an annular weld between the outer rims of the ele-

ments 30 and 32. Therefore, the present R.F. circuit constitutes a substantial advancement over prior R.F. cavity circuits for tubes of the described type which generally involve at least several machined parts including threaded retaining caps and locking screws.

The R.F. output from the pill box circuit structure comprises a coaxial line generally designated 34 which includes a tubular outer conductor 35 brazed to the rim of an aperture formed in the side of the member 30 and an inner conductor 36 having an inductive loop portion bearing against the ceramic insulator between the anode rings 21 and electrically contacting one of said rings. The outer end of the coaxial line extends through an aperture in the side of the magnet subassembly and is sealed therein by a quantity of sealing or potting compound 37 which will be discussed in greater detail hereinafter in connection with the method whereby the disclosed apparatus is manufactured. The outer end of the coaxial line 34 includes a conventional threaded section for effecting coupling to external R.F. circuitry.

As seen in FIGURES 1 to 3, the R.F. circuit is mounted in the magnet subassembly on a metal diaphragm 38 which is adapted for being clamped between the casings 5a and includes apertured tabs 39 for receiving the bolts 7 for this purpose. As best seen in FIGURE 2, the diaphragm 38 is centrally apertured and has the pill box R.F. circuit brazed thereto with the shoulder 31 on the R.F. circuit positioned in the diaphragm aperture. Additionally, and as best seen in FIGURE 3, the diaphragm 38 includes diametrically opposed cutouts to provide space for extension of the coaxial output 34 and D.C. leads which will be described in detail hereinafter. Further the diaphragm 38 includes oppositely extending ribs 40 and 41 on either side of the magnetron which adapts the diaphragm for greater flexibility to facilitate adjustable positioning of the magnet in the R.F. circuit secured to the diaphragm. Still further, the diaphragm is preferably formed of a high thermal conductivity material such as copper, thereby to provide for substantial heat transfer outwardly from the magnetron to the magnet subassembly for dissipation thereby.

As seen in FIGURES 2, 4 and 5, the D.C. connections to the magnetron are made through upper and lower planar contact structures generally designated 42 and 43, respectively, interposed between the ends of the magnetron and the inner ends of the pole pieces 11. More specifically, the upper contact structure generally designated 43 includes a lower metal plate-like member 44 having an apertured cup-shaped section 45 engaging the upper surface of the upper anode ring 21 of the magnetron and brazed to the inner rim of the upper member 32 of the R.F. circuit. The contact structure 42 also includes a generally planar metal member 46 which is bonded about the rim thereof to the rim of the lower member 44 to form therewith a casing or planar sheath-like conductive structure defining a space therein. Inserted in this sheath-like structure are lower and upper planar dielectric elements 47 and 48, respectively. The lower dielectric element 47 includes an aperture 50 which is coaxial with the aperture in the bottom of the section 45 of the lower metal member 44. Disposed in the aperture 50 are the inner ends of three D.C. connector elements two of which comprise leaf-like spring contact members 51. Another connector 52 constitutes a wire-like element disposed between the members 51. The connector elements 51 and 52 are secured at their outer ends to a portion of the dielectric element 47 located externally of the sheath-like structure described above. Additionally, the elements 51 and 52 extend between the elements 47 and 48 and are thereby insulated from the sheath-like structure. The inner ends of the elements 51 are adapted for electrically engaging the button contacts 23 on the magnetron which provide connection to the heater element 22 in the magnetron and the central wire-like lead 52 makes electrical contact with the button contact 25 which provides electrical connection to the control electrode.

The outer ends of the leads 51 and 52 are secured to the lower dielectric member 47 by means of conductive rivets 53. As seen in FIGURES 2 and 4, flexible wire leads 54 are affixed to the rivets 53 for extending externally of the magnet subassembly to appropriate D.C. power circuitry. Strain on the leads 54 is relieved by a connector arrangement 55 suitably secured in an aperture in the magnetron subassembly. If desired, the connector 55 can contain R.F. attenuators shown in outline and designated 56. This type of connector and the attenuator elements contained therein are disclosed and claimed in copending U.S. patent application No. S.N. 98,045 of E. J. Cooke, filed March 24, 1961, now U.S. Patent No. 3,134,950 and assigned to the same assignee as the present invention.

In my disclosed contact structure 42 the center lead 52 is provided with a small cross sectional area and thus serves as high impedance to R.F. energy also. This structure is provided in view of the fact that D.C. leads of the voltage tunable magnetron tend normally to transmit and radiate an undesirably high level of R.F. energy. This R.F. energy is generally coupled by the tube elements and thus transmitted by the D.C. leads connected to the tube elements. The coupling and transmission of R.F. energy along the D.C. leads tends to result in loading of the tube additional to that provided by the R.F. output assembly. Variations in this additional loading results when the positions of the leads are changed or when the leads are touched as by a human operator. The D.C. leads radiate R.F. energy and any changes in the shape or size of an external enclosure will result in variations of tube loading. These variations in loading result in undesirable, uncontrolled perturbations of the power spectrum and the tuning linearity. In the described structure the thin lead 52 serves to reduce R.F. energy tending to be transmitted thereby and radiated therefrom and thus serves to minimize the just-discussed problem.

The lower D.C. contact structure 43 illustrated in detail in FIGURE 5 is similar to the upper one 42 described above. Specifically, and as illustrated in FIGURES 2, 3 and 5, the lower structure 43 comprises upper and lower metal plate-like conductive members 57 and 58, respectively, bonded about the edges thereof to complete a planar sheath-like structure defining a space therein. The upper member 57 is formed with an aperture having an upstanding rim 59 which is brazed to the lower side of the subassembly comprising the R.F. circuit and diaphragm. Additionally, the aperture 59 provides access to the end cap 17 of the magnetron on which the cold cathode 18 is mounted. Inserted in the space between the members 57 and 58 are two superposed dielectric planar elements 60 and 61, respectively. The upper element 60 includes an aperture 62 which registers with the opening in the member 57 and carries a D.C. lead 63 which can be substantially identical in structure and function to the lead 52 in the upper contact structure 32. Specifically, the lead 63 is adapted for both providing a D.C. connection with the magnetron cold cathode contact and for reducing R.F. energy appearing thereon. The lead 63 is electrically connected to a conductive rivet 64 in the element 60 in the same manner as the connector element in the structure 42 described above. A flexible lead 54 is connected to the rivet 64 and extends to the exterior of the package assembly through the connector 55 mounted in the side of the magnet subassembly.

Secured to the outer surfaces of each of the contact structures 42 and 43, as by spot welding, is a retaining ring 65 adapted for confining a quantity of bonding or potting material designated 66 in FIGURE 2. The potting material 66 is disposed between the inner end of each of the pole pieces 11 and the adjacent D.C. contact structures 42 and 43 and is form fitted therebetween to conform to the adjacent pole piece and contact structure.

More specifically, the material **66** can be any high heat conductivity cementitious or bonding material which is adapted for holding the unitary circuit subassemblies comprising the magnetron and R.F. and D.C. circuits rigidly in place between the pole pieces and for affording substantial thermal transfer from the magnetron to the magnet subassembly through the pole pieces. Additionally, the bonding material **66** is adapted for serving as a filler in the space between the pole pieces and circuit structure.

In the device illustrated the bonding material **66** is both thermally and electrically conductive. Further, depending on the operating conditions contemplated, the bonding material **66** can be relied upon as the sole means for supporting the magnet and circuitry and associated circuitry in the magnet subassembly in which case the diaphragm **36** can be eliminated. In such an arrangement the bonding material would constitute the sole thermal and electrical conductive paths between the magnetron circuitry and magnet subassembly. Also, if it should be desired that the magnet subassembly and tube circuitry be operated at different electrical potentials, the bonding material can be electrically insulative as well as thermally conductive. Preferably, bonding material **66** can constitute any one of those materials generally available and referred to in the industry as "potting compounds." Such compounds are available with a variety of physical characteristics and properties, thermal and electrical conductivities, hardnesses after curing or setting and curing schedules. One such compound found particularly effective is designated Eccoband Solder #56C and is available through Emerson & Cummings, Inc., Canton, Massachusetts. The same type of compound can be utilized in forming the coaxial output seal **36** and, if desired, the material for forming this seal can be placed in position and cured at the same time as the material **66** bonded to the pole pieces **11**.

In practicing the method aspect of my invention, I construct the magnet and circuit subassemblies separately. More specifically, I construct as a unitary subassembly the R.F. circuit including the coaxial output **34**, with the magnetron **4** captured therein and with the diaphragm **38** and D.C. contact structures **42** and **43** brazed to the R.F. circuit. Additionally, I construct as separate unitary structures the opposed dish-shaped magnet segments **5**, including the attached casings **5***a* and the removable pole pieces **11**. Then I assemble these unitary structures and the D.C. lead connector **55** which is also separately assembled and attached to the D.C. contact structures **42** and **43** in the manner illustrated in FIGURES 1 and 2. However, at this point in the construction, the bonding material **66** and the output seal **37** are not provided. Then the magnet pole pieces are locked in position in the inserts **10**. Thereafter with the aid of a fixture adapted to hold the magnet subassembly and contained magnetron and circuit assembly in any relative adjusted position I apply D.C. operating voltages to the package and, while operating the tube, I manipulate the coaxial output **34** of the R.F. circuit for moving the circuit and thereby adjustably position the axis of the magnetron contained in the R.F. circuit relative to the magnetic field between the pole pieces. This adjustive manipulation of the R.F. circuit is continued until the relative adjusted position of the tube and magnetic field afford maximum operating performance. When this is attained, the subassemblies are held fixedly in the desired adjusted positions as by locking the fixture holding the subassemblies. Then the pole pieces **11** are unlocked and removed and a soft or uncured quantity of the bonding material, or potting compound, is introduced into each of the retaining cups **65** through the inserts **10** in the magnet subassembly. Additionally, a quantity of the bonding or potting material is positioned in the magnet subassembly aperture about the coaxial output **34** to provide the seal **37**. Following this operation, the pole pieces are reinserted and locked in the adjusted positions illustrated in FIGURE 2 by turning in the locking screws **15**. It will be noted that in these positions the inner ends of the pole pieces are inserted into the compound and form or mold the compound in conforming and close fitting relationship therewith but at the same time, are spaced from the contact structures **42** and **43** in order to avoid disturbing the relative adjustment of parts and to allow for disposition therebetween of the bonding material. Thereafter, the material **66** and **36** are caused to set, cure or harden, as by heating at a prescribed temperature for a prescribed time schedule where one of the bonding or cementitious materials referred to commonly as "potting compound" is employed. The disposition of the bonding material between the inner faces of the pole pieces and the circuit subassembly provides for substantially greater adherence than if, for example, the bond extended only to the side surfaces of the pole pieces. Additionally, this provides for heat paths of substantially large cross-sectional areas to conduct heat outwardly from the tube to the magnet subassembly which serves as a heat sink.

It is to be understood, however, that any suitable bonding material which can be positioned in the magnet subassembly between the circuit structure and pole pieces and is effective for securely joining the unitary subassemblies comprising the magnet and R.F. and D.C. circuitry and the pole pieces can be employed.

Additionally, as indicated above, for some applications the diaphragm **36** may not be desired or required. My above-described method for assembling a voltage tunable magnetron package is adapted for manufacturing and adjusting this type of structure also in which case, however, the diaphragm would not be present to assist in locating the magnetron in an initial substantially coaxial position and holding it fixed in an adjusted position after manipulation of the coaxial output. Therefore, extra care will be required in manipulating the coaxial output and holding the subassembly in the desired adjusted position until the bonding material is effective for rigidly joining the several subassemblies and thus holding the attained adjustment. However, once the bonds are effected they can be relied upon for holding the adjustment and providing substantial heat transfer from the magnetron to the magnet subassembly.

While I have shown and described specific embodiments of my invention, I do not desire my invention to be limited to the particular form shown and described, and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed spaced pole pieces, a unitary circuit subassembly including a radio frequency cavity circuit having an electric discharge device including electrode contact surfaces on opposed ends thereof mounted in said circuit subassembly and with said contact surfaces exposed, a D.C. contact structure securely affixed to each of the opposed sides of said radio frequency circuit and including means making electrical contact with said contact surfaces of said device, said circuit subassembly being positioned between said pole pieces with said device in a predetermined adjusted position relative to the magnetic field between said pole pieces and with said D.C. contact structures interposed between said pole pieces and the ends of said device and spaced from said pole pieces, and a thermally conductive metal-to-metal bond material interposed between and conforming to each said D.C. contact structure and its adjacent pole piece for rigidly supporting and maintaining said predetermined adjusted position of said device relative to said magnetic field.

2. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed axially spaced apart pole pieces defining a transverse gap therebetween, a unitary circuit subassembly having an electric discharge

device mounted in the said defined transverse gap in a predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween, said circuit being axially spaced from each of said pole pieces, a quantity of bonding material extending transversely between and engaging said circuit subassembly and each said pole pieces rigidly maintaining said device in said predetermined adjusted position, said bonding material being thermally conductive.

3. Radio frequency apparatus comprising a magnet subassembly including a pair of removable pole pieces and means for locking same in said subassembly in predeterminedly spaced relation, a unitary circuit subassembly having an electric discharge device mounted therein in a predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween, said pole pieces being securely locked in spaced relation to said circuit subassembly, a D.C. contact casing structure securely affixed to each of the opposed sides of said unitary circuit subassembly, and a quantity of thermally conductive bonding material interposed between said casings and each said pole pieces filling and conforming to the space therebetween, rigidly maintaining said device in said predetermined adjusted position and providing thermal paths of substantial cross-sectional areas between said device and said magnet subassembly.

4. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed spaced pole pieces, a unitary circuit subassembly having an electric discharge device mounted therein in a predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween, and a thermally conductive diaphragm having portions extending from opposed sides of said circuit subassembly and affixed to said magnet subassembly, and a quantity of thermally conductive non-metallic bonding material extending between and engaging said circuit subassembly and each said pole pieces and conforming thereto to rigidly maintain said device in said predetermined adjusted position.

5. Radio frequency apparatus comprising a magnet subassembly including a pair of joined opposing dish-shaped permanent magnet segments defining an enclosed space and having a pair of pole pieces extending in opposed spaced coaxial relation to said enclosed space, a unitary circuit subassembly including radio frequency and D.C. circuit elements contained in said space and having an electric discharge device mounted therein in a predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween and radio frequency output and D.C. circuit connections extending through openings in said magnet subassembly, and a quantity of thermally conductive conforming bonding material extending between said circuit subassembly and each said pole pieces rigidly maintaining said device in said predetermined adjusted position and providing substantial thermal paths between said device and magnet subassembly.

6. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed dish-shaped permanent magnet segments and means joining the rims of said segments to define an enclosed space, each of said magnet segments carrying a removable pole piece and means for locking same in predeterminedly extending positions therein, said pole pieces being adapted for extending coaxially in said enclosed space, a unitary circuit subassembly contained in space and having an electric discharge device mounted therein in a predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween, said pole pieces being securely locked in spaced relation to said circuit subassembly, and a quantity of thermally conductive bonding material interposed between said circuit subassembly and each of said pole pieces, filling the space therebetween by conforming to said pole piece and said circuit subassembly, rigidly maintaining said device in said predetermined adjusted position and providing substantial thermal paths between said device and magnet subassembly.

7. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed dish-shaped permanent magnet segments defining an enclosed space and carrying a pair of pole pieces extending in opposed spaced coaxial relation in said enclosed space, a unitary subassembly including radio frequency and D.C. circuit elements contained in said enclosed space, said circuit elements being carried on a thermally-conductive diaphragm having the outer edges thereof extending between said magnet segments and joined thereto, said radio frequency circuit element having an electric discharge device mounted therein in a predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween, and a quantity of thermally conductive bonding material extending between and conforming to said circuit subassembly and each said pole pieces rigidly maintaining said device in said predetermined adjusted position and providing substantial thermal paths between said device and magnet subassembly.

8. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed dish-shaped permanent magnet segments and means joining the rims of said segments to define an enclosed space, each of said magnet segments carrying a removable pole piece and means for locking same in predeterminedly extending positions therein, said pole pieces being adapted for extending coaxially in said enclosed space, a unitary circuit subassembly including radio frequency and D.C. circuit elements contained in said enclosed space, said circuit elements being carried on a thermally conductive diaphragm having the outer margin thereof extending between said magnet segments and joined thereto, said radio frequency circuit elements having an electric discharge device mounted therein in predetermined adjusted position between said pole pieces and relative to a magnetic field therebetween, said pole pieces being securely locked in spaced relation to said circuit subassembly, and a quantity of thermally-conductive bonding material interposed and formed between said circuit subassembly and each said pole pieces filling the space therebetween, rigidly maintaining said device in said predetermined adjusted position and providing substantial heat paths between said device and magnet subassembly.

9. Radio frequency apparatus comprising a magnet subassembly including a pair of joined opposed dish-shaped permanent magnet segments defining an enclosed space and carrying a pair of pole pieces in opposed spaced coaxial relation in said enclosed space, a unitary circuit subassembly including, a radio frequency cavity circuit having an electric discharge device including electrical contact surfaces on opposed ends thereof mounted in said circuit and with said contact surfaces exposed, a D.C. contact structure securely affixed to each of the opposed sides of said radio frequency circuit and including means making electrical contact with said contact surfaces of said device, said circuit subassembly being positioned between said pole pieces with said device in a predetermined adjusted position relative to a magnetic field between said pole pieces and with said D.C. contact structure interposed between said pole pieces and the ends of said device and spaced from said pole pieces, a metal-to-metal bond material interposed and formed between each said D.C. contact structure and its adjacent pole piece for filling the space therebetween and rigidly maintaining said predetermined adjusted position of said device relative to said magnetic field.

10. Radio frequency apparatus comprising a magnet subassembly including a pair of opposed dish-shaped permanent magnet segments and means joining the rims of said segments to define an enclosed space, each of said segments carrying a removable pole piece and means for locking same in a predeterminedly extended position therein, said pole pieces being adapted for extending in

spaced coaxial relation in said enclosed space, a unitary circuit subassembly disposed in said enclosed space and including a heat-conducting diaphragm secured between the side walls of said magnet subassembly and extending in a plane transverse the axis of said pole pieces, a radio frequency cavity circuit mounted on said diaphragm and having an electric discharge device including electrode contact surfaces on the opposed ends thereof mounted in said cavity circuit with said contact surfaces exposed, a D.C. contact structure securely affixed to each of the opposite sides of said circuit and including means making electrical connections with said contact surfaces of said device, said circuit subassembly being positioned between said pole pieces with said device in a predetermined adjusted position relative to a magnetic field between said pole pieces and with said D.C. contact structures interposed between said pole pieces and the adjacent ends of said device, said pole pieces being securely locked in position in spaced relation to said circuit subassembly, and quantities of thermally conductive bonding material interposed between said contact structures and said pole pieces filling the spaces therebetween, rigidly mounting said device in said preadjusted position and providing substantial thermal paths between said device and magnet subassembly.

11. In combination, an interdigital magnetron including an evacuated envelope having a longitudinally spaced pair of anode rings sealed in the wall of said envelope, a radio frequency cavity circuit consisting of two annular sheet-metal members having outer diameters greater than the outer diameters of said anode rings, at least one of said members being cup-shaped and having a centrally apertured bottom with an outwardly extending recess therein tightly receiving one of the anode rings of said magnetron, and the other of said members having the inner rim thereof bearing on the outer surface of the other of said anode rings and being secured to the outer rim to the rim of said cup-shaped member, whereby said magnetron is rigidly retained coaxially positioned in said cavity circuit.

12. In combination, an interdigital magnetron including an evacuated envelope having a longitudinally spaced pair of anode rings sealed through the wall of said envelope, and a radio frequency cavity circuit consisting of a conductive cup-like element of greater diameter than said anode rings and including a centrally apertured bottom having an outwardly extending annular stepped section extending about said aperture and having an outer diameter corresponding generally to the diameter of one of said anode rings, said magnetron having one end extending through said aperture and one of said anode rings positioned in said stepped section of said cup-like member, and said annular conductive member fitted over the other end of said magnetron and having the rim thereof joined to the rim of said cup-like member, and said annular conductive member having an annular inner rim engaging and bearing on the outer surface of the other of said anode rings, whereby said magnetron is rigidly retained coaxially positioned in said cavity circuit, and a coaxial output coupler including an outer conductor bonded to a lateral opening in said cup-shaped member and an inductive coupling loop protruding inwardly in said cavity circuit between said anode rings.

13. In combination, an interdigital magnetron including an evacuated envelope having a longitudinally spaced pair of anode rings sealed in the side wall of said envelope and at least one contact surface on each end thereof, a radio frequency cavity circuit having said magnetron mounted retainedly therein consisting of two annular sheet metal members having diameters greater than the diameters of said anode ring, at least one of said members being cup-shaped and having a centrally apertured bottom with an outwardly extending recess therein tightly receiving one of the anode rings of said magnetron, and the other of said members having the inner rim thereof bearing on the upper surface of the other of said anode rings, a metal joint material joining the outer rim to the rim of said cup-shaped member, whereby said magnetron is rigidly retained coaxially positioned in said cavity circuit, and a planar metal sheath rigidly affixed to each side of said radio frequency circuit, each said sheaths including an apertured side overlying an end of said magnetron, each of said sheaths carrying therein at least one electrical connector insulated therefrom and making electrical contact with the contact surface on said magnetron through the apertured side of said sheath, and an electrical connection in at least one of said sheaths comprising also a radio frequency attenuator.

14. A D.C. lead connector for making electrical connection to a device having a contact surface at an end thereof, comprising a planar conductive sheath adapted for extending transverse an end of said device and having an aperture in one side thereof, a pair of superposed dielectric plate-like members inserted in said sheath and having exposed outer portions, one of said plate-like members having an aperture registering with the aperture in said sheath, at least one conductive connector extending between said plate-like members and having its outer end secured by conductive fastening means to one of said plate-like members at said opposed outer portion, said connector having an inner end portion exposed through said aperture for making contact with said contact surface on a device, and at least one of said connectors comprising a radio frequency attenuator.

15. A D.C. lead connector for making electrical connection to a device having contact surfaces at an end portion thereof, comprising a planar conductive sheath adapted for extending transverse an end of said device and having an aperture on one side thereof, a pair of superposed dielectric plate-like members inserted in said sheath and having exposed outer portions, one of said plate-like members having an aperture registering with the opening in said sheath, a plurality of conductive connectors extending between said plate-like members and having their outer ends secured by conductive fastening means to one of said plate-like members at the exposed portion thereof, said connectors having inner end portions exposed through said aperture for making engagement with said contact surfaces on a device, and at least one of said connectors comprising a resilient leaf spring and the other comprising a radio frequency attenuator.

16. The method of manufacturing radio frequency apparatus comprising the steps of forming a magnet subassembly having a pair of opposed pole pieces adapted for being both removable and locked in position in said subassembly, positioning between said pole pieces a circuit subassembly having a magnetron device fixedly mounted therein in a position generally coaxial with a magnetic field between said pole pieces, operating said magnetron and concurrently adjustably positioning same relative to said magnetic field until optimum magnetron operation is attained, fixedly holding said magnetron and circuit in the relative positions in which optimum operation is attained, removing the pole pieces from said magnet subassembly, applying a quantity of thermally conductive bonding material to each side of said circuit subassembly, and reinserting said pole pieces and effecting a rigid bond between each said pole pieces and said circuit subassembly.

17. The method of manufacturing radio frequency apparatus according to claim **16** and comprising the further step of locking the reinserted pole pieces in spaced relation to said circuit element, thereby to insure the presence of said bonding material between the inner faces of said pole pieces and said circuit subassembly to enhance adhesion and heat conduction between the joined elements.

18. The method of manufacturing radio frequency apparatus comprising the steps of forming a magnet subassembly with a pair of opposed pole pieces adapted for

being both removable and locked in position in said subassembly, mounting between said pole pieces a deformable conductive diaphragm, carrying a circuit assembly having a magnetron device fixedly mounted therein in a position generally coaxial with a magnetic field between said pole pieces, operating said magnetron and concurrently adjustably positioning same relative to said magnetic field by deforming said diaphragm until optimum magnetron operation is attained, fixedly holding said magnetron and said magnet and circuit subassembly in the relative positions in which optimum magnetron operation is attained, removing the pole pieces from said magnet subassembly, applying a quantity of thermally conductive bonding material to each side of said circuit subassembly, and reinserting said pole pieces and imbedding the inner ends thereof in said bonding material to effect rigid bonds between each said pole pieces and said circuit subassembly and to provide substantial thermal paths therebetween.

19. The method of manufacturing radio frequency apparatus comprising the steps of arranging and securing together a pair of dish-shaped permanent magnet segments to define in enclosed space, mounting a pair of opposed pole pieces in said segments in a manner for being both removable and lockable in position in said magnet segments, positioning in said enclosed space and between said pole pieces a circuit subassembly having a magnetron fixedly mounted therein and in a position generally coaxial with a magnetic field between said pole pieces and having further a coaxial radio frequency output extending through an opening in the side of said magnet subassembly, operating said magnetron and concurrently adjustably positioning same relative to said magnetic field by manipulating said output externally of said

enclosed space until optimum magnetron operation is attained, fixedly holding said magnet and circuit subassemblies in the relative positions in which the optimum magnetron operation is attained, removing the pole pieces from said magnet subassembly, applying a quantity of thermally conductive bonding material to each side of said circuit subassembly and about the portion of said radio frequency output protruding through said opening in said magnet subassembly, and reinserting said pole pieces and effecting a rigid bond between each said pole pieces and said circuit subassembly and between said radio frequency output and said magnet subassembly.

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