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Lewis

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[54] **COUPLING ARRANGEMENTS IN RESONANT DEVICES**

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[52] **U.S. Cl.**......... **333/83 R;** 315/39.53; 315/39.57; 315/39.61; 331/90; 333/99 MP

[51] **Int. Cl.**......................... **H01j 23/32;** H01j 23/20

[58] **Field of Search** .... 333/83 R, 82 B, 99 MP, 333/97 S, 13; 315/39.53, 39.55, 39.57, 39.61; 331/90

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Assistant Examiner—Wm. H. Punter
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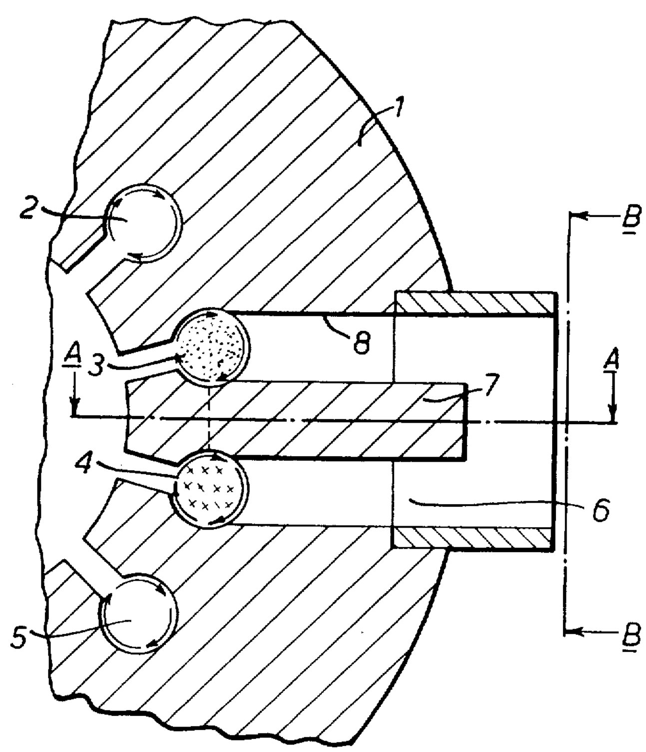
[57] **ABSTRACT**

The invention relates to resonant devices such as cavity magnetrons having a plurality of resonant cavities in a common block of which at least two adjacent cavities exhibit magnetic fields of opposing phase. In order to achieve coupling to or from the device a coaxial transmission line formed by an annular hole of constant cross sectional dimensions is provided extending into the block, such that a portion of the annular hole to one side of the inner wall forming member breaks into one of the two cavities and a portion of the annular hole to the opposite side of the inner wall forming member breaks into the other of the two cavities. The transmission line may be used to effect tuning of the device by coupling tuning means to the end of the hole remote from the cavities.

10 Claims, 6 Drawing Figures



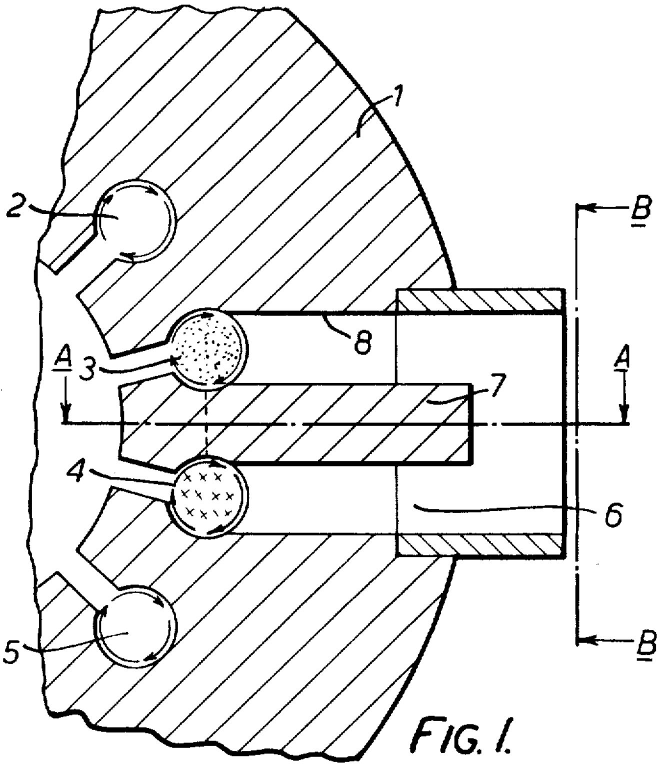


FIG. 1.

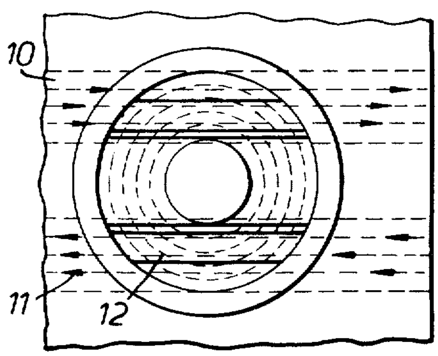


FIG. 3.

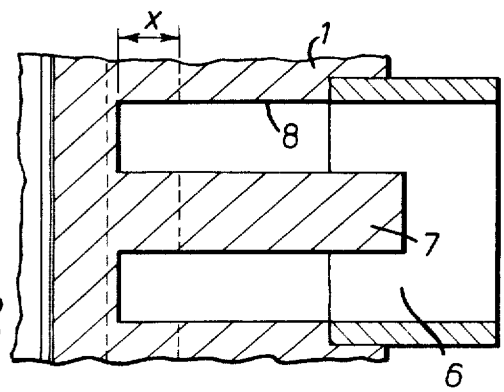


FIG. 2.

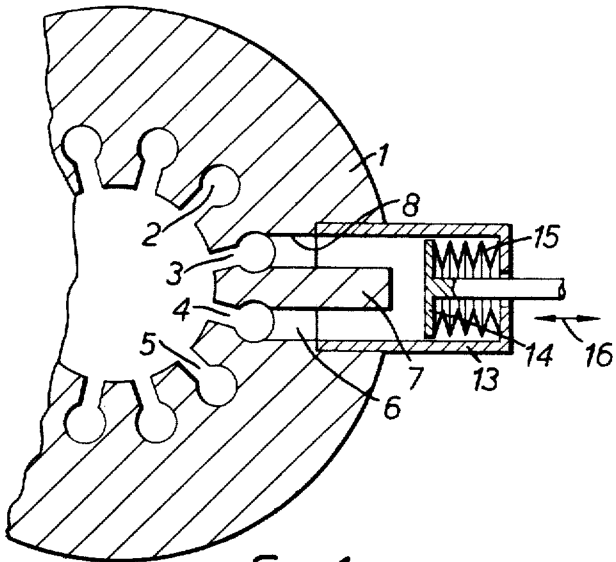


FIG.4.

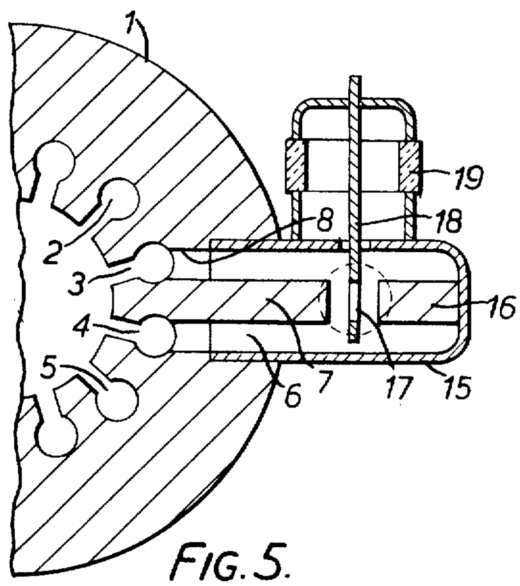


FIG.5.

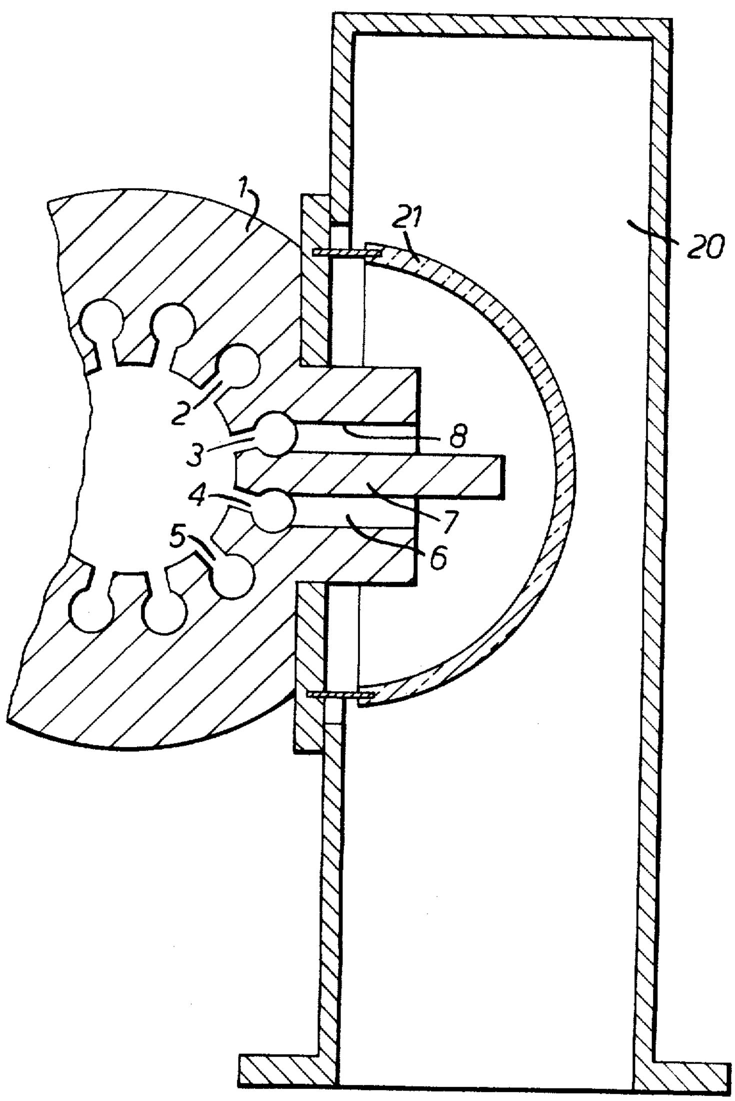


FIG. 6.

COUPLING ARRANGEMENTS IN RESONANT DEVICES

This invention relates to resonant devices and in particular to resonant devices of the kind having a plurality of resonant cavities at least two of which exhibit, in operation, magnetic fields of opposing phase. Cavity magnetrons are examples of such devices.

The present invention seeks to provide a resonant device of this kind with improved means of energy coupling with the resonant cavities of the device.

According to this invention a resonant device has a plurality of resonant cavities in a common block at least two adjacent ones of which exhibit in operation magnetic fields of opposing phase, coupling to or from said device being effected by a co-axial transmission line formed by an annular hole of at least substantially constant cross-sectional dimensions extending into said block such that a portion of the annular hole to one side of the inner wall forming member breaks into one of said two cavities and a portion of the annular hole to the opposite side of said inner wall forming member breaks into the other of said two cavities.

The outer wall of said hole forms the outer conductor of said transmission line whilst the inner wall forming member of said hole forms the inner conductor of said transmission line. The inner wall forming member of said hole continues into the common wall between said two cavities.

The extent to which the annular hole breaks into said two cavities, or in other words the width of the communicating slot formed in each of said two cavities where said annular hole communicates therewith, is chosen in dependence upon the amount of coupling which is desired between said two cavities and the co-axial transmission line.

The co-axial transmission line may be utilised to couple energy out of said device, but preferably the co-axial transmission line is utilised to effect tuning of said device.

Where the co-axial transmission line is utilised to effect tuning of the said device means may be provided for varying the value of reactance presented by the transmission line to said two cavities where they communicate with the transmission line.

In one embodiment of the invention, a conductive cylinder is provided to extend the outer wall of said annular hole away from said two cavities beyond the inner wall forming member and a tuning piston is provided in said cylinder adjustable to move towards or away from the end of said inner wall forming member.

In another embodiment of the invention, a multipactor discharge arrangement is provided at the end of said transmission line remote from said cavities, the whole arrangement being such that change in capacitance of said multipactor discharge arrangement causes the reactance presented to each of said two cavities where they communicate with said transmission line to be altered.

The invention is illustrated in and further described with reference to the accompanying drawings in which,

FIG. 1 is a section through part of a magnetron arrangement in accordance with the present invention,

FIG. 2 is a part section along the line A—A of FIG. 1,

FIG. 3 is a view in the direction of the arrows B of FIG. 1, illustrating the interaction between the magnetic fields in two resonant cavities and the magnetic field corresponding to current flowing in a transmission line provided in accordance with the present invention to couple with said cavities,

FIG. 4 is a section through a magnetron in accordance with the present invention showing particularly a tuning arrangement therefor,

FIG. 5 is a section through another magnetron arrangement in accordance with the present invention in which tuning is effected by a multipactor discharge arrangement and

FIG. 6 is a section through another magnetron arrangement in accordance with the present invention showing in particular an output arrangement provided by the present invention.

In all of the drawings like references are used to denote like parts.

Referring to FIG. **1**, in accordance with normal practice the magnetron is provided with an anode block **1** having a plurality of resonant cavities of which only four, referenced **2**, **3**, **4** and **5** are shown. As is well known, in operation, alternate cavities exhibit magnetic fields of opposite phases. Thus, cavities **3** and **4** are of opposite phases, the magnetic field of cavity **3** being taken to extend out of the plane of the drawing and the magnetic field of cavity **4** being taken to extend into the plane of the drawing as viewed and as represented conventionally.

In order to provide energy coupling with the magnetron, an annular hole **6** is provided to extend into the anode block **1** to communicate with the two cavities **3** and **4**. As will be seen the annular hole **6** breaks into the walls of the cavities **3** and **4** to an extent "x", best seen in FIG. **2**, where x is the distance between the outermost points of the cavities and the inner end of the hole. The inner wall forming member **7** of annular hole **6** forms the central conductor of the co-axial transmission line thus formed, whilst the outer wall **8** of the annular hole **6** forms the outer conductor of the transmission line. It will thus be seen that a portion of the annular signal path to one side of the inner wall forming member **7** communicates with resonant cavity **3**, whilst a portion of the annular signal path to the opposite side of the inner wall forming member **7** communicates with the resonant cavity **4**. The extent to which coupling between the cavities **3** and **4** and the transmission line **7**, **8** is provided is determined by the extent to which the annular hole breaks into the cavities, i.e. distance x in FIG. **2**, or in other words the width of the communicating slot formed in each of the cavities **3** and **4**.

The cross-sectional dimensions of the annular hole **6** are constant throughout its length from the outer wall of the anode block **1** to the point at which it breaks into the cavities **3** and **4**.

The effect achieved in operation is best seen from FIG. **3**, in which the arrowed dashed lines **10** represent the magnetic field in cavity **3**, the arrowed dashed lines **11** represent the magnetic field in cavity **4**, whilst the arrowed dashed lines **12** represent the magnetic field corresponding to TEM mode current flowing in transmission line **7**, **8**. With the magnetic fields in cavities **3** and **4** in antiphase, these will match the direction of the magnetic field **12** which is created in the transmission line **7**, **8** so that the transmission line couples with the resonant cavities **3** and **4**.

The extent to which the annular hole **6** communicates with the resonant cavity **3** and **4** may be varied over wide limits. The distance x may be almost zero so that very narrow slots appear in the walls of the resonant cavities **3** and **4** to provide a relatively low degree of coupling, or it may be large so that a significant length of the inner wall forming member **7** of the transmission line will extend between the two cavities **3** and **4** to provide a relatively high degree of coupling.

Referring to FIG. **4**, this illustrates one use of the transmission line **7, 8** to effect tuning of the magnetron. The outer walls **8** of the transmission line are extended well beyond the inner conductor formed by inner wall forming member **7** by means of a conductive cylinder **13.** Conductive cylinder **13** contains a piston **14,** sealed by means of bellows **15,** which may be adjusted to and fro in the direction of the doubled headed arrow **16.** The piston can therefore be moved towards or away from the end of the inner wall forming member **7.** This movement, varies the reactance of the end of the transmission line remote from the resonant cavities **3** and **4** which, with the length of the transmission line chosen appropriately, is transformed into a variable reactance at the end of the transmission line where it communicates with the resonant cavities **3** and **4,** thus varying the frequency of these cavities to effect tuning of the magnetron.

Referring to FIG. **5,** the principal of tuning in this case is similar to that involved with the arrangement shown in FIG. **4** except that in this case the piston **14** is replaced by a multipactor discharge arrangement formed by extending the inner wall forming member **7** to form one multipactor discharge electrode, extending the outer walls **8** by a closed cylinder **15** from the closed end of which extends a stub **16** forming a second multipactor discharge electrode and providing a common secondary emitting multipactor discharge electrode **17** between the ends of the extended inner wall forming member **7** and the stub **16,** whereby multipactor discharge may be initiated. As will be seen the common electrode **17** is supported by a conductor **18** which extends outside the evacuated space of the cylinder **15,** by means of an insulated feed-through arrangement **19.** The principal of multipactor discharge devices is well known per se and need not be explained here. Again the change in capacitance brought about as a multipactor discharge is initiated by applying a suitable potential between conductor **18** and the walls of the cylinder **15** is transformed at the end of the transmission line where it communicates with the cavities **3** and **4** as a change in reactance altering the resonant frequency of these two cavities.

Referring to FIG. **6,** in this case the transmission line **7, 8** is utilised for coupling out energy from the magnetron into a waveguide **20.** Both the outer walls **8** and the inner wall forming member **7** are extended into the waveguide **20,** where they are permitted to radiate in order to excite the normal Ho1 mode of the waveguide. The end of the transmission line **7, 8** within the waveguide **20** is covered by a dome **21** of dielectric material which permits radiation, but which forms a vacuum tight seal between the evacuated interior of the magnetron and the signal path of the transmission line, and the unevacuated inside of the waveguide **20.** In many cases such an output arrangement may be preferred to conventional output coupling arrangements, since with the arrangement shown in FIG. **6** the load is shared between the two cavities **3** and **4,** instead of being taken from one single cavity as was previously the case.

I claim:

1. A resonant device having a plurality of resonant cavities in a common block at least two adjacent ones of which exhibit in operation magnetic fields of opposing phase, and a co-axial transmission line formed by an annular hole of at least substantially constant cross-sectional dimensions throughout its length extending into said block only to such depth that a portion only of the annular hole to one side of the inner wall forming member breaks into one of said two cavities and a portion only of the annular hole to the opposite side of said inner wall forming member breaks into the other of said two cavities to effect coupling to or from said device while leaving said inner wall forming member integrally joined with said block.

2. A resonant device as claimed in claim **1** and wherein means are provided for varying the value of reactance presented by the transmission line to said two cavities where they communicate with the transmission line to effect tuning of the said device.

3. A resonant device as claimed in claim **2** and wherein a conductive cylinder is provided to extend the outer wall of said annular hole away from said two cavities beyond the inner wall forming member and a tuning piston is provided in said cylinder adjustable to move towards or away from the end of said inner wall forming member.

4. A resonant device as claimed in claim **2** and wherein a multipactor discharge arrangement is provided at the end of said transmission line remote from said cavities, the whole arrangement being such that change in capacitance of said multipactor discharge arrangement causes the reactance presented to each of said two cavities where they communicate with said transmission line to be altered.

5. A resonant device comprising an anode block having at least a pair of adjacent and parallel resonant cavities each of substantially constant cross section and which in operation exhibits magnetic fields of opposite phases extending lengthwise in said cavities, and a coaxial transmission line of substantially constant cross section throughout coupled to said resonant cavities; said transmission line being defined within a cavity having a closed outer end portion and an inner wall surface of substantially constant cross section extending at least from adjacent said closed outer end portion axially normal to a plane containing the axes of said cavities and into intersection with said cavities, and a member of substantially constant cross section projecting coaxially within said cavity from that portion of the anode block between said cavities to a region spaced from said closed end portion of the cavity, said inner wall surface and said member constituting said transmission line and defining an annular hole of substantially constant cross section with the outer dimension of said hole transverse of the plane containing the axes of said cavities being greater than the spacing between said axes but less than the transverse spacing between those surfaces of the cavities which are most remote from each other, and with the inner transverse dimension of said hole being less than said spacing between said axes but greater than the transverse spacing between those surfaces of the cavities which are closest together, whereby said member is integral with said block and forms the inner conductor of the coaxial transmission line while said wall surface forms the outer conductor thereof and with said transmission line being coupled to said cavities to a degree dependent upon said transverse dimensions of the annular hole.

6. A resonant device according to claim **5** wherein each of said cavities, said wall surface and said member are of cylindrical cross section.

7. A resonant device as defined in claim **6** wherein said closed end portion is defined by an end wall intersecting the outer end of said wall surface, said member terminates in spaced relation from said end wall, and including a tuning device disposed between said member and said end wall.

8. A resonant device as defined in claim **7** wherein said tuning device is in the form of a piston movable toward and away from said member.

9. A resonant device as defined in claim **8** wherein said tuning device is in the form of a multipactor discharge device.

10. A resonant device as defined in claim **6** wherein said closed outer end portion is defined by a dome of dielectric material enclosing the outer end of said transmission line.

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