Dec. 16, 1969 R. A. DEHN 3,484,861

MULTIPLE BEAM R.F. APPARATUS TUNER

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FIG.1.

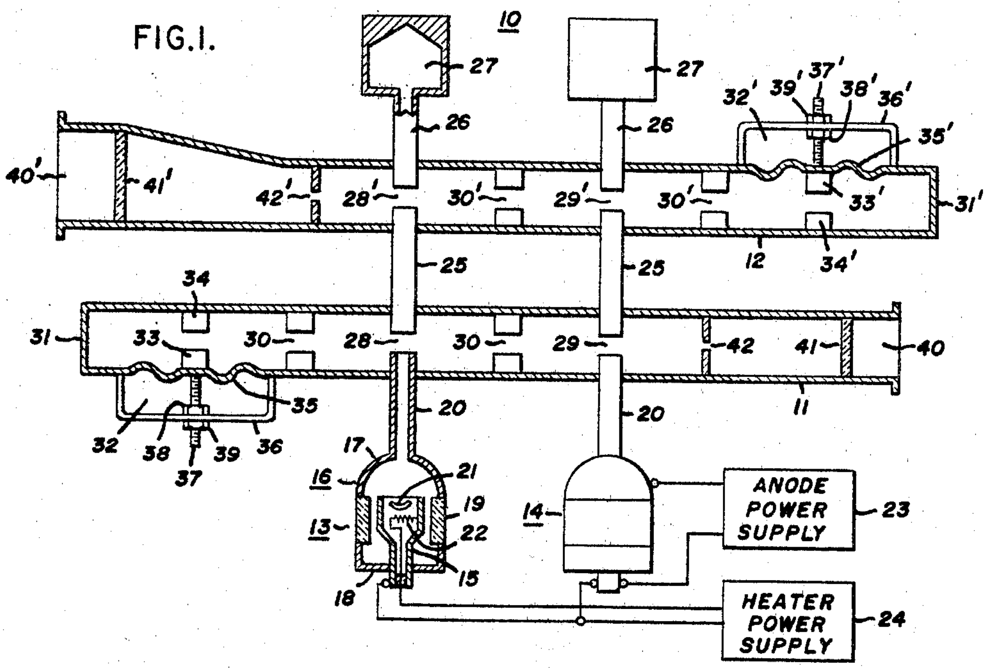

FIG.2.

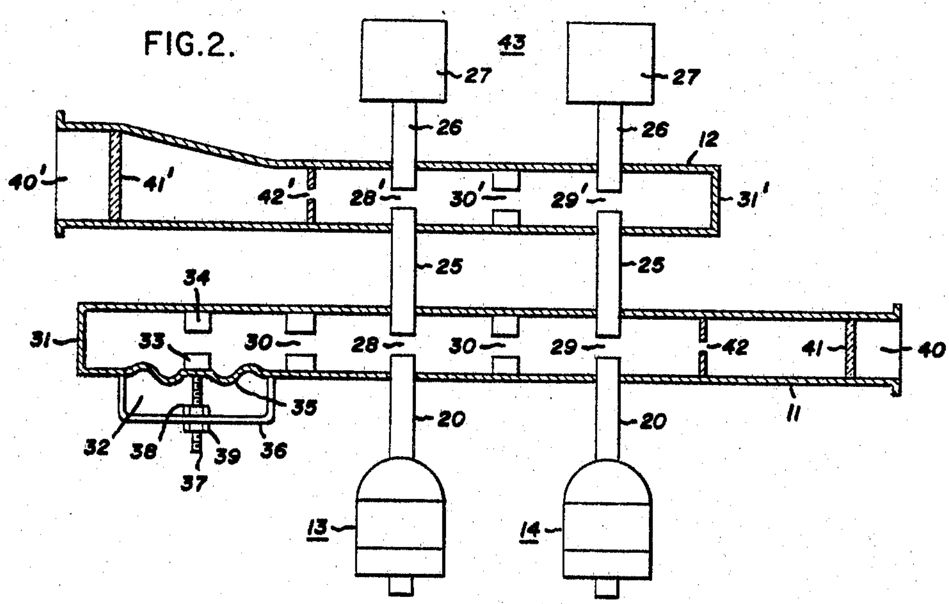

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FIG.3.

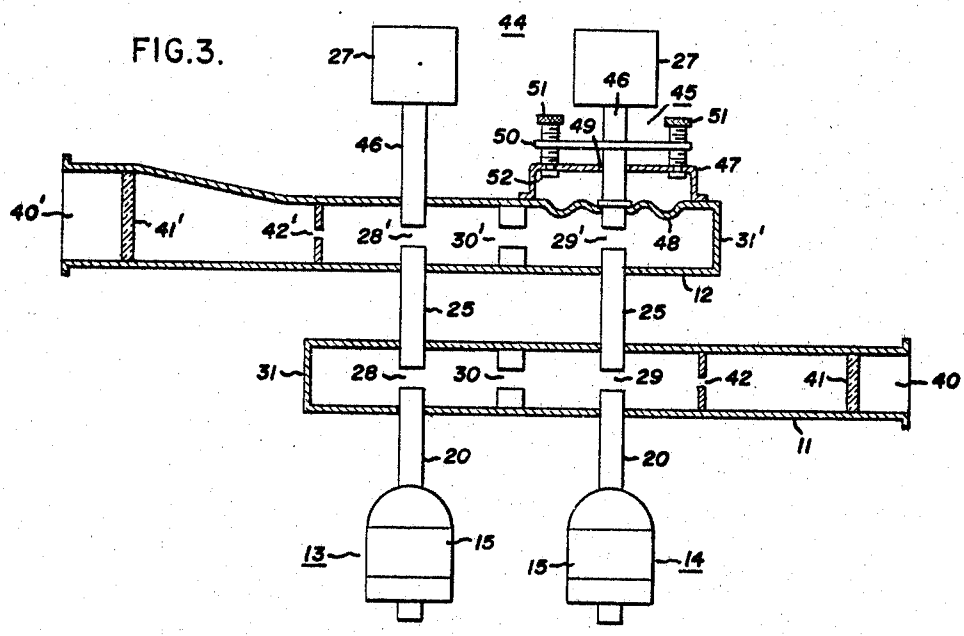


FIG.4.

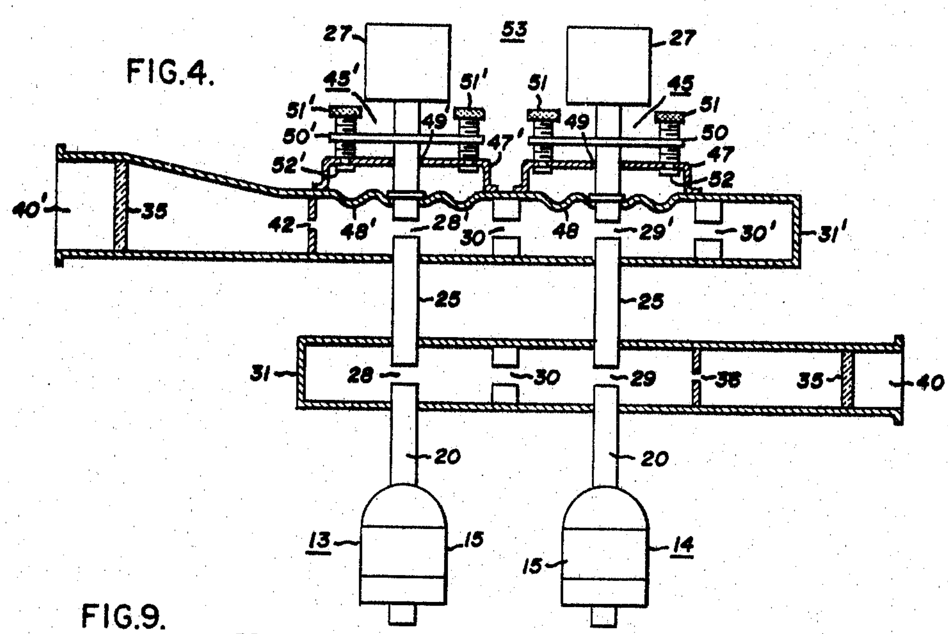
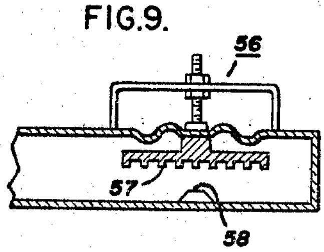


FIG.9.



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MULTIPLE BEAM R.F. APPARATUS TUNER

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FIG.5.

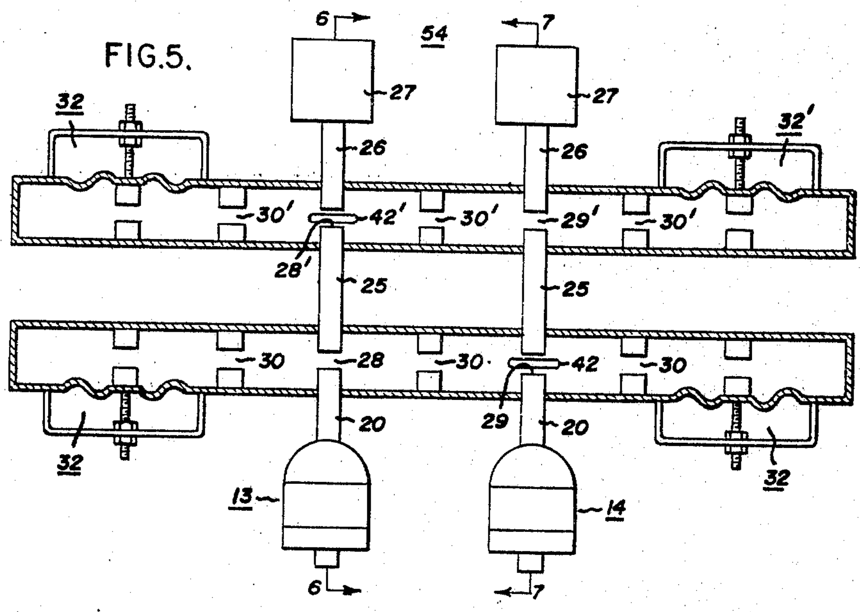


FIG.6.

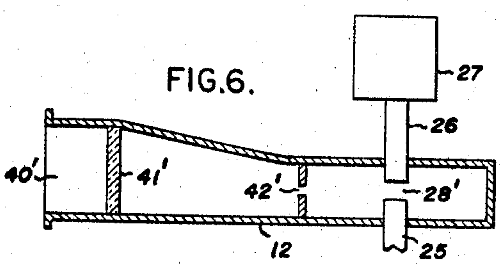


FIG.7.

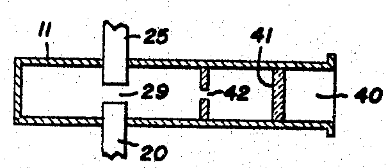
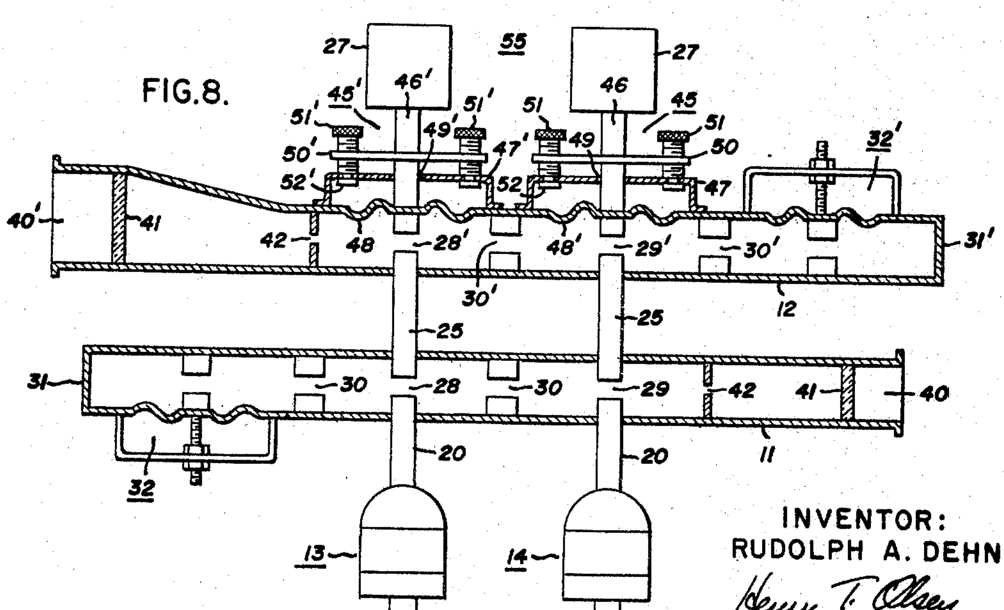


FIG.8.



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MULTIPLE BEAM R.F. APPARATUS TUNER

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Continuation-in-part of application Ser. No. 379,688, July 1, 1964. This application Oct. 25, 1967, Ser. No. 678,062

Int. Cl. H01j 25/02

U.S. Cl. 315—5.16 13 Claims

ABSTRACT OF THE DISCLOSURE

A multiple beam klystron apparatus which is capacitively tuned to different frequency by adjustment of active or passive capacitive gaps.

This is a continuation-in-part of my copending application S.N. 379,688, now abandoned filed July 1, 1964, and assigned to the same assignee.

This invention relates to multiple beam R.F. apparatus capable of generating and handling relatively high electromagnetic wave power at relatively high frequencies and more particularly to new and improved means for tuning such apparatus.

The resonant circuits for most forms of microwave or ultra high frequency equipment are cavity resonators whose resonant frequencies are determined by the cavity geometry and mode of oscillation. For any particular mode of oscillation, the frequency may be changed by altering the cavity size, for example, by moving one or more of the walls of the cavity resonator, or in effect, by having a movable protrusion element projecting into the cavity. In relatively low power devices, electrical continuity of a movable element within the cavity may be maintained by means of sliding plungers or contact fingers. These sliding contacts, however, are not generally suitable at either high power outputs or in vacuum conditions since the sliding and contacting metal surfaces may be welded to each other. In addition, a poor contact between the sliding members would generally lower the Q or sharpness of tuning of the resonator. In other types of high power vacuum equipment, the resonator size is sometimes controlled by utilizing deforming resonator walls or by employing bellows arrangements. These means usually have the disadvantages of limited tuning range, low mechanical durability, or undesirable inductance. When a number of single R.F. devices are combined in the form of a multiple beam R.F. device and are cooperatively associated for combined power output, the tuning problem becomes effectively more difficult because of the larger volume of resonator which is necessary to contain the several beam devices.

Accordingly, it is an object of this invention to provide an improved multiple beam R.F. apparatus incorporating an improved frequency tuning means.

It is another object of this invention to provide improved capacity tuning of a multiple beam R.F. apparatus.

It is a further object of this invention to provide active gap tuning of multiple beam R.F. apparatus at predetermined and selected active gap locations.

It is yet another object of this invention to provide gap tuning of a multiple beam R.F. apparatus by means of extra "active" gaps, i.e., a passive gap at an electrical maxima active gap position but not having electron traversal and therefore not active in the sense of adding energy to the standing wave.

It is still another object of this invention to provide a multiple beam R.F. apparatus adapted for high power operation and minimal mode interference difficulties

having improved means for tuning the apparatus which includes laterally spaced variable extra "active" gaps in opposite waveguides.

Further objects and advantages of this invention will become more apparent as the following description proceeds, and the features of novelty which characterize this invention will be pointed out with particularly in the claims annexed to and forming a part of this specification.

Briefly described, this invention in one preferred embodiment includes the combination of a multiple beam R.F. apparatus which comprises input, output, and if desirable, at least one intermediate longitudinally resonant waveguide all supported in spaced parallel relation, the input and output waveguides having power coupling means. Extending perpendicular to and through the waveguides in operative association with each are a plurality of parallel klystron-like beam devices and one or more passive or dummy capacitance means positioned in alternate, sequential, predetermined spaced relationship. Each of such beam devices includes a plurality of axially spaced drift tubes which define input, output and one or more intermediate capacitive interaction active gaps positioned in respect ones of the mentioned waveguides, an electron gun for projectng a beam of electrons through the drift tubes past the interaction gaps, and a collector for collecting the electrons emerging from the last drift tube. The tuning means of this invention includes means such as a flexible wall portion to vary the gap spacing between one or more gap defining elements. The gap may be one of the active interaction gaps or a further sequential extra "active" gap, i.e., one not having electron beam traversal but located at an active gap position in the sequence. An optimum tuning means position includes one variable extra "active" gap at an end location in one waveguide, and another variable extra "active" gap in an adjacent waveguide at an opposite end, each of the "active" gaps being remote from the power coupling means of its respective waveguide.

This invention will be better understood when taken in connection with the following description and the drawings in which:

FIG. 1 illustrates a preferred embodiment of this invention having adjustable extra "active" gaps in opposite ends of opposite waveguides;

FIG. 2 illustrates a modification of the invention in FIG. 1 employing a single variable extra "active" gap;

FIG. 3 illustrates another modification of this invention whereby in a multiple beam klystron an active beam traversing gap is adjustable;

FIG. 4 illustrates a further modification of the invention as shown in FIG. 3 wherein all active gaps in the output waveguide are adjustable;

FIG. 5 illustrates a double ended tuner for a multiple beam klystron;

FIG. 6 is a side view of FIG. 5 along the line A—A;

FIG. 7 is an opposite side view of FIG. 5 along the line B—B;

FIG. 8 is a schematic representation of an embodiment of this invention wherein all gaps are adjustable;

FIG. 9 is a modification of gap defining elements.

A particular multiple beam R.F. apparatus to which this application is preferably applicable is described and claimed in copending U.S. Patent No. 3,248,597 M. R. Boyd et al. filed Feb. 16, 1962, and assigned to the same assignee as the present invention. In the mentioned application there is disclosed and claimed a multiple beam R.F. apparatus which is particularly adaptable for generating and handling substantially high electromagnetic wave power at microwave frequencies and in a manner effective to minimize mode interference problems of the type heretofore encountered in multiple beam devices.

Also the mentioned apparatus is adapted for generating and handling power levels equivalent to the total power of a plurality of individual single beam R.F. power generating devices. The present invention includes the combination of suitable R.F. apparatus of the above-described type, as one example, which incorporates new and improved means of readily and selectively varying the frequency determining characteristics of resonator sections over a predetermined range. The various sections of the device are thus adapted to be easily tunable to any desired operating frequency within the predetermined ranges. The present invention also includes preferred structure by which such tuning is attainable without degrading or adversely affecting the above-mentioned desirable operating capabilities of the apparatus.

An operative example of a preferred embodiment of this invention in combination with a multiple beam R.F. apparatus as above described is illustrated in FIG. 1. Referring now to FIG. 1, the multiple beam R.F. apparatus **10** includes as one example an input waveguide resonator **11** and an output waveguide resonator **12** positioned in parallel spaced opposed relationship. If desirable, one or more intermediate waveguides may be positioned between the input waveguide **11** and the output waveguide **12**. Extending perpendicularly to and through waveguides **11** and **12** are a plurality of, for example, two klystron beam devices **13** and **14**. Each of these beam devices is similar so that a description of one suffices for the other. Beam devices **13** and **14** include a well known type of electron gun generally illustrated at **15**. Gun **15** is contained within a housing **16** which includes an upper section **17** and a lower section **18**, separated by an intermediate high voltage insulation member **19**. Housing **16** is connected to a tubular section **20** which is sealed to and extends re-entrantly in one side of the input resonator **11**. The electron gun **15** also includes an electron emitter which in one form may include an emissive element **21** which is indirectly heated by a heater element **22**. Klystron units **13** and **14** are connected to suitable sources of power supply indicated generally as **23** and **24** in the usual manner. To electron gun **15** is therefore adapted to direct a beam of electrons axially through tube section **20**. Axially aligned with each tube section **20** and interconnecting the resonators or waveguides **11** and **12** is a drift tube **25**. Also axially aligned with drift tube **25** and positioned in the output waveguide resonator **12** is a further tubular section **26**. The end of tube section **26** is closed with or fitted with an electron collector electrode **27**. In the described arrangement, the tubular sections **20**, **25** and **26** extend re-entrantly in the waveguides to define therein re-entrant active capacitive gaps or elements **28** and **29** in waveguide **11**, and **28'** and **29'** in waveguide **12** with the capacitance of each gap in each waveguide being originally substantially equal.

As illustrated in FIG. 1, these active gaps **28** and **29** in the input waveguide, and gaps **28'** and **29'** in the output waveguide, are periodically laterally spaced along each waveguide. In accordance with one feature of the above-mentioned copending application, there is positioned midway between each pair of adjacent active gaps in each resonator, a passive or dummy capacitive element **30** or **30'** in the form of a passive or dummy gap. The lateral spacing of the beam devices **13** and **14** from each other and from the passive gaps as well as the spacing between dummy gaps are generally correlated relative to the field maxima of a given mode in the resonator and the frequency separation of the various possible resonant modes. The resulting structure may then be considered to be as a length of a waveguide periodically loaded with capacitors. In the illustrated waveguide **11** of FIG. 1, two active gaps **28** and **29** are illustrated in combination with two alternate passive capacitive gaps **30**, the capacitance values of all gaps being substantially equal. In the alternating relationship of active and passive gaps, the next gap element to be included in the input waveguide **11** would be, for example, in logical sequence from klystron device **14** to waveguide end **31**, an additional klystron device such as **13** or **14**. In this instance, however, the next active gap location or position does not include a klystron beam device, for example such as **13** and **14**, but instead includes a variable capacitance means in one form as a gap device **32**, the gap spacing of which is adjustable for tuning purposes. This gap device **32** is substantially equidistantly spaced not only from the next adjacent dummy gap **24** but also preferably from the closed end wall of waveguide **10**.

The variable gap **32** is in one form of this invention generally similar to the dummy gaps **30** and active gaps **28**, **29**, etc., and comprises at least one movable member **33** which is spaced from an opposite member **34**. Motion of member **33** toward and away from member **34** may be provided by various means known in the art. For example, one such means includes a flexible wall member **35** constituting a part of the wall portion of waveguide **11** and adapted to provide motion of member **33**. Such motion may be fixed in any position through means of a simple mechanical structure, for example, as a frame or bridge member **36** which spans the flexible wall portion **35** and surrounds movable member **33**. One or more mechanical adjusting means, for example in the form of threaded rod **37**, is slidably passed through frame **36** and attached to the flexible wall portion **35** to adjustably position member **33** through various positions relative to the fixed position of frame **36**. Adjustable securing means in the form of lock nuts **38** and **39** are utilized on rod **37** adjacent opposite sides of frame **36**.

The output waveguide or resonant member **12** includes similar structure and a similar arrangement of elements as described for the input resonator **11**, with the exception that, as illustrated in FIG. 1, the particular elements in the output resonator **12** are in reverse lateral order. The end wall **31'** of the output resonator **12** is laterally opposite or remote from the end wall **31** of input resonator **11**. From that point there follows a variable extra "active" gap **32'** similar in all respects to that variable extra "active" gap **32** as described in the input resonator, a spaced passive or dummy gap **30'**, a spaced active gap **29'**, a spaced dummy gap **30'**, and a further active spaced gap **28'**. The gap members as described are similar to the corresponding gap members in the input resonator.

In accordance with known klystron operation, a standing electromagnetic wave is established in the input waveguide by any suitable R.F. input coupling means to which waveguide **11** is connected through flange opening **40**. As another example, the input waveguide **11** may be adapted to have a well known inductive coupling loop connected thereto as illustrated and described in the mentioned copending Boyd application. An input window **41**, and an iris power coupling **42** for loading purposes are employed in the usual manner and a standing wave is provided in the input waveguide **11**. This wave has electric field maxima occurring at each of the active gaps **28**, **29** and extra "active" gap **32**, and an electric field minimum or nodes occurring at each passive gap **30**. An electrical field minimum also occurs at the boundary of the wageguide, end wall **31**.

The active gaps **28** and **29** comprise interaction gaps and therefore the electrons in each of the electron beams passing across these gaps become velocity modulated in the gaps in a manner well known to those skilled in the klystron art. After passing through the drift tubes **25** for a suitable and predetermined distance, the electron beams each become density modulated in accordance with the input signals to the input resonator, also in a manner well known to those skilled in the art. The density modulated electron beams or bunches in the beams pass through active gaps **28'** and **29'** and cooperatively induce in the output resonator **12** an amplified standing electromagnetic wave corresponding in form to the electromagnetic wave established in the input resonator **11** in a manner similar to that which is well known in the klystron art. The electromagnetic wave induced in the output resonator **12** also has electric field maxima occurring at each of the active gaps **28′** and **29′** and extra "active" gap **32′** and electric field minima occurring at each of the passive gaps **30′** and closed end wall **31′**. This electromagnetic wave energy can be extracted through power coupling iris **42′** and window **41′** in the usual manner. The electrons constituting the beams are collected in the electron collector electrodes **27**.

An electromagnetic wave in either of the waveguide resonators **11** and **12** is presented, for example, in waveguide **11** with periodically arranged capacitances in the form of active capacitive gaps **28** and **29** and extra "active" gap **32**, and passive capacitive gaps **30** and end wall **31**. Thus each waveguide **11** or **12** is in effect an electrically short-circuited section of a periodically loaded waveguide with the periodic loading afforded by alternate active and passive gaps respectively. Adjusting the active gaps in the manner described to change the gap spacing between members **33** and **34**, for example, changes the capacitance value of the gap and has the effect of varying adjustably over a predetermined range, the frequency determining characteristics of the waveguide without substantial distortion of the field patterns in the waveguide. The variation of capacitance in the tuner gap modifies the field pattern in the waveguide, as do other tuning means, but adverse changes as occur, in this invention are negligible over a resonable tuning range for example, 2 to 3% of the operating frequency. The limitation in tuning range is generally predicated on the mechanical flexibility limits of the diaphragm flexible wall or by the permissible distortion of the electric field at the beam gap nearest the tuning gap. Thus tuning of the resonant sections of the device can be accomplished with minimum distortion of the field patterns which afford the maximum efficiency energy exchange between the electromagnetic waves in the waveguides and the traversing beams which further does not adversely affect the desired mode separation. The maximum tuning range of this tuner is determined by both mechanical considerations and by distortion of the desired mode pattern. With a single tuner gap and 10 electron or klystron beams, for example, a tuning range of two to three percent has been achieved without significant distortion. Best results are obtained in the practice of this invention with a variable gap tuning means positioned in each of the input and output waveguides as illustrated in FIG. 1

Various modifications of the tuning means of this invention may be suitably employed with different types of multiple beam klystron devices. For example, in FIG. 2 there is illustrated a modification **43** of this invention which includes, in general, the same basic structure as described for the apparatus of FIG. 1 with the exception that only one variable capacitance active gap adjustable device **32** is illustrated. This single adjusting device **32** may be utilized in either waveguide **11** or **12** as long as it is in the end of the waveguide remote from the power coupling means, i.e., irises **42** or **42′** and is shown preferably, for example, in the input waveguide **11** in the same position as adjustable gap **32** in input waveguide **11** of FIG. 1. Since the extra "active" gap is eliminated from waveguide **12**, the end wall **31′** is located at the electrical minimum next adjacent active gap **29′**.

This invention is not restricted to adjustable waveguide gaps wherein the adjustable gap excludes a traversing electron beam. For example, referring to FIG. 3, there is illustrated a multiple beam R.F. device **44** in accordane with a preferred practice of the invention where an adjustable active gap **45** is utilized in combination with a beam device **14**, as illustrated in FIG. 1. For example, the klystron beam device **14** comprises an electron gun **15**, a collector **27**, and intermediate drift tubes **20**, **25** and **46**, as known in the art and described for FIG. 1. Surrounding drift tube **46** on the outside surface of the

output waveguide **12** is an adjustable gap means **45** similar in effect to the adjusting means described with respect to FIG. 1. For example, a frame or bridge member **47** spans the flexible wall portion **48** of waveguide **12**, while at the same time being provided with an aperture **49** to slidably receive drift tube **45**. Drift tube **46** with collector **27** attached includes a flange member **50** which is fixedly attached to drift tube **46** and overlies bridge member **47**. Adjusting means in the form of one or more turning members **51** are employed to vary the gap spacing **29′**. Turning member **51** passes through and threadedly engages flange member **50** but engages bridge member **47** by means of an axially fixed rotatable bearing **52**. Rotation of member **51** will raise or lower drift tube **46** depending on the flexibility of diaphragm **48**. The active gap adjustable means may be associated with either input or output waveguides intermediates waveguides, or various predetermined combinations as long as the gap remote from the power coupling means is variable. An optimum arrangement for the FIG. 3 modification includes an adjustable beam traversing gap in the output waveguide **12**, together with spaced passive gap **30′** as illustrated and described.

The modification as illustrated in FIG. 4 utilizes the active beam traversing variable gap means of FIG. 3 in an arrangement where a plurality of the active gaps include variable adjusting means. These adjustable gaps may be adjacent gaps or spaced gaps and be associated with one or more waveguides. As illustrated in FIG. 4, one preferred device **53** includes a pair of adjacent active gaps **45** and **45′** which are adjustable, and each of which is in output resonator **12**. As in FIGS. 1–3, the modification of FIG. 4 also includes the spaced passive gap members **30**, **30′** et cetera of FIGS. 1–3 and for the reasons as described. It is to be noted, however, that tuning may be advantageously accomplished by varying of gaps **45** and **45′** together or by varying gap **45** by itself. Varying of gap **45′** by itself leads to decoupling of beam device **14** from the output waveguide **40′** with a result serious reduction in power output.

The tuning means of this application may also be applied to other modifications of this invention. For example, a double ended symmetrical tuner for a wider tuning range is illustrated in FIG. 5. Referring now to FIG. 5, there is shown an endwise cross-sectional view of a multiple beam klystron unit **54**, with a plurality of glystron beam devices **13** and **14** providing active gaps **28**, **28′**, **29** and **29′**, et cetera, as described with respect to FIGS. 1 through 4. Capacitance loading gaps **30**, **30′** et cetera are also indicated as shown. In this modification of the invention, extra "active" gaps **45** are provided at each end or side of the waveguides **11** and **12**. For any particular waveguide both tuning means of that waveguide are adjusted not necessarily precisely in synchronism but approximately alike. For example, both ends could be moved in unison for large frequency changes and fine tuning may involve but one adjusting means. FIGS. 6 and 7 illustrate side views of the FIG. 5 modification taken along lines **6—6** and **7—7** of FIG. 5. These side views show parts of the input and output waveguides **11** and **12**. It will be noted that power coupling inlet **42** and outlet **42′** are located active gap positions and, therefore, either of extra "active" gaps **32** and **32′** are remote from power coupling means with respect to the beam gaps.

This invention is particularly adaptable to the tuning of all active and extra "active" gaps of a multiple beam glystron. For example, referring now to FIG. 6, there is illustrated a multiple beam klystron device **55** similar to that of FIG. 1, with the exception that the active gap tuning means of FIG. 3 is employed for each of the active gaps of FIG. 1.

As in all embodiments of this invention, tuning may be accomplished on an individual basis, or gang tuning may be employed for one or more tuning means. Furthermore, the variable capacitance gap means may take the form of other capacitance variance means and also other gap means including, for example, variable posts, concentric cylinders, et cetera. One particular modification of an active gap is illustrated in FIG. 9. Referring now to FIG. 9, the adjustable active gap **56** includes a movable member **57** in the form of a wide flat element which shields the thin flexible wall portion **48** from potential arcing. The opposite gap member **58** may also take various forms such as a truncated cone which, as illustrated, provides in combination with member **57** a capacitance substantially equal to the other gap means such as **28**, **29** and **30**.

The adjustable gap tuning means of this invention is operative to change the electrical phase delay of the overall line section to thereby change the frequency. The adjustable gap means also provides increased tuning range while at the same time having a mechanical simplicity which may be easily cooled. The mentioned advantages are important ones considering other tuning means, which may be favorable electrically but not desirable insofar as ease of manufacturing, maintenance, operability, and cooling is concerned.

A particular application for which this invention is readily adaptable is the combination of the tuning means of this invention together with other tuning means where the tuning means of this invention is the finer tuning portion. For example, a gap tuner may be the fine tuner for a movable wall device where the gap tuner is part of the large movable wall.

The multiple beam R.F. device of this invention is usually surrounded by a solenoid coil which provides a collimating magnet field extending parallel to the axis of the beam devices and adapted to focus the several electron beams. The entire assembly may also be enclosed by casing of a material effective to provide uniformity of axial magnetic field in the region through which the electron beams pass.

While this invention has been described with reference to particular and exemplary embodiments thereof, it is to be understood that numerous changes can be made by those skilled in the art without actually departing from the invention as disclosed, and it is intended that the appended claims include all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A multiple beam glystron device comprising in combination

(a) at least a pair of resonant waveguide sections having power coupling means,

(b) one of said sections constituting an input resonator and the other of said sections constituting an output resonator,

(c) means defining a row of predetermined spaced apart positions along said waveguides for locating a plurality of klystron beam devices therein,

(d) a plurality of passive capacitive elements in said waveguide in alternate and equidistant relationship to said klystron beam device positions,

(e) a plurality of klystron beam devices extending through said waveguide at said klystron beam device positions and defining active electron beam interaction gaps therein,

(f) said active gaps and passive capacitive elements having substantially equal capacitance values and defining electric field maxima and minima respectively on establishment of a standing electromagnetic wave in said input waveguide,

(g) and variable capacitance means in at least the klystron beam device position most remote from the power coupling means, the gap spacing of which is adjustable to change the output frequency of said device.

2. A multiple beam klystron device comprising in combination

(a) at least a pair of resonant waveguide sections having power coupling means,

(b) one of said sections constituting an input resonator and one of said sections constituting an output resonator,

(c) means defining a row of predetermined spaced apart positions along said waveguides for locating klystron beam devices therein,

(d) a plurality of passive capacitive elements in said waveguide in alternate and equidistant relationship to said klystron beam device positions,

(e) a plurality of klystron beam devices extending through said waveguides at said klystron beam device positions and defining active electron beam interaction gaps therein,

(f) said active gaps and capacitive elements having substantially equal capacitance values and defining electric field maxima and minima respectively on establishment of a standing electromagnetic wave in said input waveguide,

(g) and variable gap means in at least the klystron beam device position most remote from the power coupling means and adjustable to change the output frequency of said device.

3. The invention as recited in claim **2** wherein a variable gap means is provided in each waveguide at the klystron beam device position most remote from the power coupling means.

4. The invention as recited in claim **2** wherein said variable gap is an electron beam traversing interaction gap.

5. The invention as recited in claim **2** wherein said variable gap is free from traversal by an electron beam.

6. The invention as recited in claim **2** wherein said variable gap is positioned adjacent an end wall of said waveguide, the said end wall being an electrical field minimum.

7. The invention as recited in claim **2** wherein said variable gap is in the output waveguide.

8. The invention as recited in claim **2** wherein each said klystron beam device positions in said output waveguide include said variable gap means.

9. The invention as recited in claim **2** wherein each said klystron beam device position in each said waveguide includes a said variable gap means.

10. A multiple beam klystron device comprising in combination

(a) at least a pair of resonant waveguide sections having power coupling means,

(b) one of said sections constituting an input resonator and one of said sections constituting an output resonator,

(c) means defining a row of predetermined spaced apart positions along said waveguides for locating klystron beam devices therein,

(d) a plurality of passive capacitive elements in said waveguide in alternate and equidistant relationship to said klystron beam device positions,

(e) a plurality of klystron beam devices extending through said waveguides at said klystron beam device positions and defining active electron beam interaction gaps therein,

(f) said active gaps and capacitive elements having substantially equal capacitance values and defining electric field maxima and minima respectively on establishment of a standing electromagnetic wave in said input waveguide,

(g) variable gap means positioned in at least the klystron beam device position most remote from power input coupling means,

(h) variable gap means positioned in at least the klystron beam device position most remote from the power output coupling means.

11. The invention as recited in claim **10** wherein each of said adjustably variable gaps is positioned in its respective waveguide adjacent the end wall thereof and opposite from the R.F. input end and output end respectively, said adjustably variable gap being in lateral spaced apart relationship.

12. A multiple beam klystron device comprising in combination

(a) at least a pair of resonant waveguide sections,
(b) one of said sections constituting an input resonator and the other of said sections constituting an output resonator,
(c) means at one end of said input waveguide to couple power input therein,
(d) means at the opposite end of the output waveguide for R.F. power output,
(e) means defining a row of predetermined spaced apart positions along said waveguides for locating a plurality of klystron beam devices therein,
(f) said plural klystron positions being along a line transversely to said input and output means,
(g) a plurality of passive capacitive elements in said waveguide in alternate and equidistant relationship to said klystron beam device positions,
(h) a plurality of klystron beam devices extending through said waveguide at said positions and defining active electron beam interaction gaps therein,
(i) said active gaps and capacitive elements having substantially equal capacitance values and defining electric field maxima and minima respectively on establishment of a standing electromagnetic wave in said input waveguide,
(j) and variable gap means in said klystron beam device positions, one on each end of said line remote from the output and input, respectively, and in each waveguide.

13. The invention as recited in claim 2 wherein said adjustable gap comprises

(a) a flexible wall means in one of said resonators,
(b) a large surface area gap member attached to said flexible wall means,
(c) and a fixed small surface gap member spaced from and opposite to said large surface area gap member,
(d) the combination of said large and said small surface area members having capacitance substantially equal to said active gaps and capacitive elements.

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