

Feb. 17, 1948.

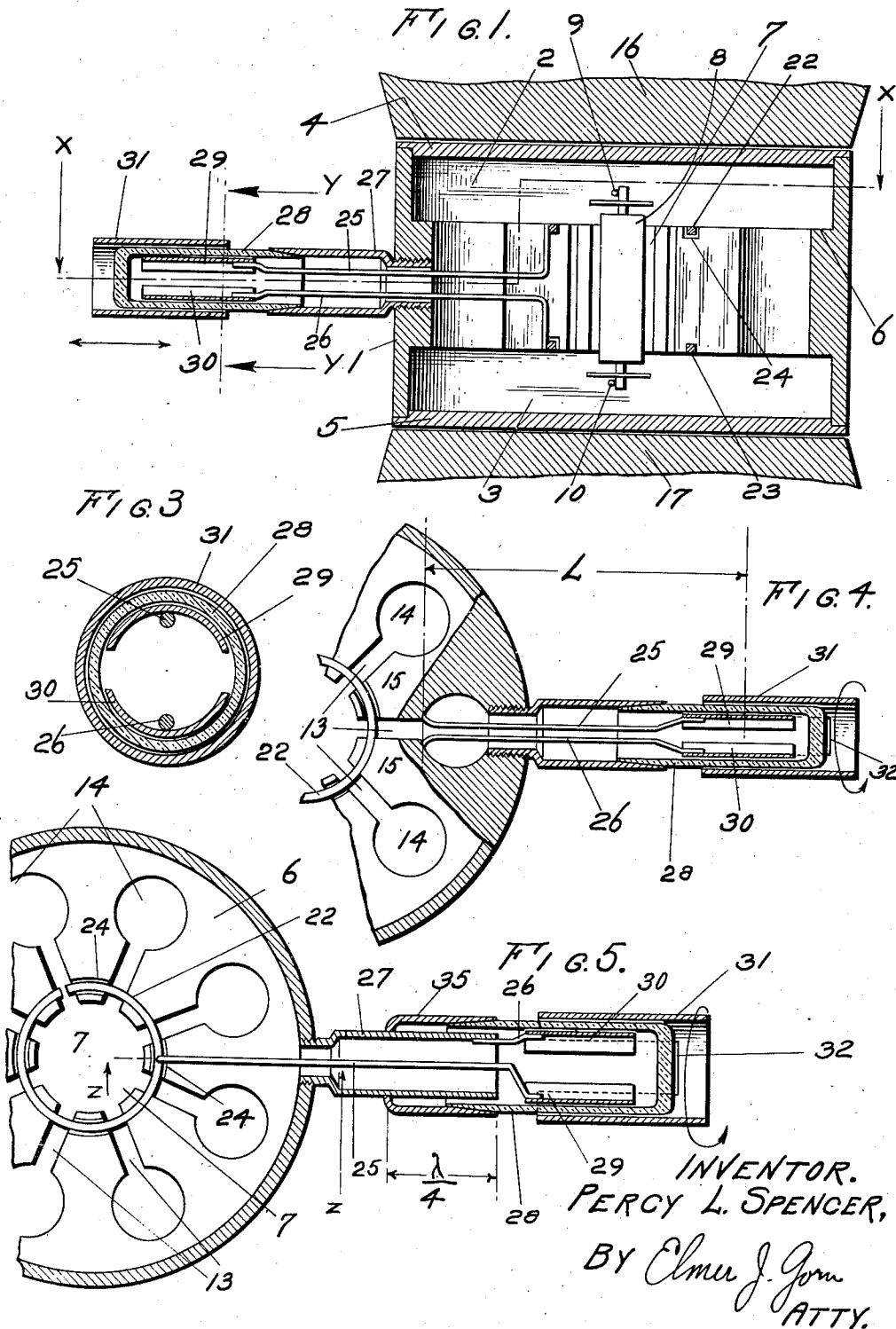
P. L. SPENCER

2,435,984

TUNABLE MAGNETRON

Filed June 2, 1944

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FIG. 2.

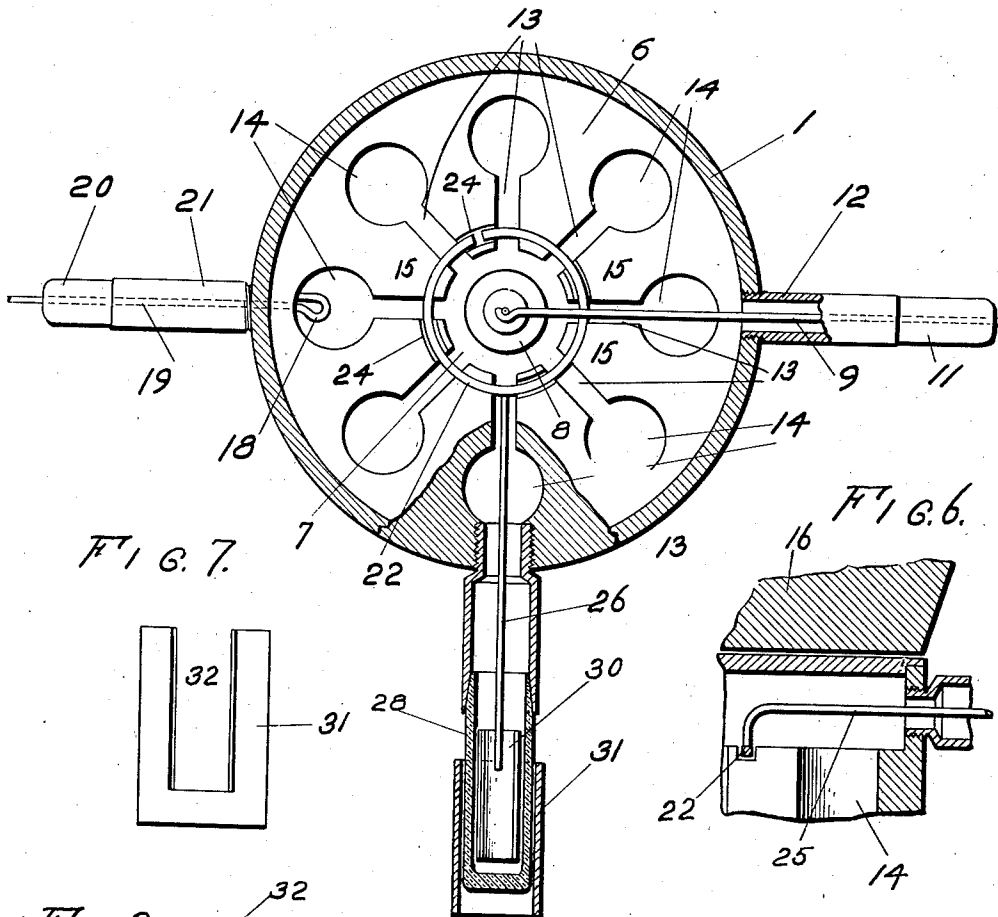


FIG. 7.

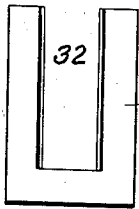


FIG. 6.

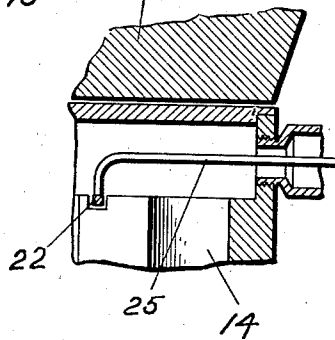
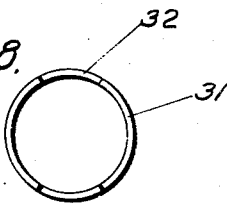


FIG. 8.



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2,435,984

TUNABLE MAGNETRON

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Application June 2, 1944, Serial No. 538,423

10 Claims. (Cl. 315—39)

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This invention relates to an electronic discharge tube of the type adapted to generate ultra-high frequency oscillations and more particularly to one in which the frequency of one or more resonant circuits within the tube determines the frequency of the oscillations produced.

In devices of the type to which the invention relates, the resonant circuit may be provided by one or more resonant chambers or cavities having inductance and capacitance and thus constituting a tuned circuit, the frequency of which is determined by the dimensions and geometry of the internal structure.

In some applications of devices of the type to which the invention relates, it is desirable to vary within limits the frequency of the oscillations generated by the tube. Heretofore it has been difficult to provide for such variation at the will of the operator since the resonant circuit which determines the frequency generated is disposed entirely within the tube, and in order to vary one of the circuit parameters determining the frequency generated, it has been the practice to provide some movable element within the tube. By varying the position of the movable element, the resonant frequency of the resonant chamber or equivalent resonant circuit of the tube is varied and accordingly the frequency of the oscillations generated is varied. The use of such a movable element greatly complicates the tube structure and since the element must be actuated from the exterior of the tube, some means must be provided for transmitting motion to the element through the exterior wall of the tube as, for example, by making a portion of the tube wall flexible. This further complicates the tube structure.

It is among the objects of the present invention to obviate the above-mentioned difficulties by providing a means whereby the frequencies generated may be controlled from a point externally of the tube and without mechanical motion therein.

It is a further object of the invention to provide a device of the type described which permits the high voltage elements of the system to be regulated inside of the evacuated portion of the tube, thus preventing the possibility of arc-over which would be present if the high voltage elements were provided with connections extending externally of the evacuated space of the tube.

It is a further object of the invention to provide a device of the type described in which changes in the adjustment of the tuning means may be effected at high speed so that the frequencies generated by the tube may be changed very

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rapidly to effect a continuous periodic variation in the frequencies generated.

The above and other objects and features of the invention will be fully set forth in the following detailed description, taken in conjunction with the accompanying drawings in which:

Fig. 1 shows a longitudinal section through a magnetron constructed in accordance with my invention;

Fig. 2 shows a section taken on line X—X of Fig. 1;

Fig. 3 shows a section through the tuning device of the tube shown in the preceding figures and is taken on line Y—Y of Fig. 1;

Fig. 4 shows a fragment of a magnetron of the type shown in Figs. 1 and 2 but provided with a modified tuning means;

Fig. 5 shows a fragment of a magnetron of the type shown in Figs. 1 and 2 provided with a further modified tuning means;

Fig. 6 shows a section taken on line Z—Z of Fig. 5;

Fig. 7 shows a side elevation; and

Fig. 8 shows an end view of a tuning ring of the type shown in Figs. 4 and 5 and suitable for use with the tuning means of any of the forms of the invention shown.

Referring to the drawings and first to the form shown in Figs. 1, 2 and 3 thereof, there is shown a magnetron comprising a block 1 of conductive material such as copper. The block 1 forms the anode and, in the instance shown, constitutes a portion of the envelope of the magnetron. The block 1 is provided with hollow end sections 2 and 3 covered by end caps 4 and 5 likewise of conductive material. Between the hollow end sections 2 and 3 is located a central bridging portion 6, having a central bore 7 within which a cathode 8 is centrally supported by a pair of lead-in conductors 9 and 10. The conductor 9 is sealed through a glass seal 11 mounted at the outer end of a conductive pipe 12 hermetically secured within the wall of the block 1 adjacent the upper hollow end section 2. The lead-in conductor 10 is likewise sealed through a similar glass seal and pipe, not illustrated, adjacent the lower hollow end section 3. A plurality of radial slots 13 extend from the bore 7 and each of the slots terminates in a cavity 14 extending through the bridging portion 6. In this way the anode structure is provided with a plurality of wedge shaped arms 15, the faces of which cooperate as anode sections with the cathode 8. Suitable magnetic poles 16 and 17 are provided adjacent the

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end caps 4 and 5 to create a magnetic field extending longitudinally of the device.

When such a device is energized oscillations are set up which may be led out from the tube by means of a coupling loop 18 extending into one of the cavities 14, one end of the loop being fastened to the inner wall of the cavity and the other end being connected to a lead wire 19 which passes through a glass seal 20 mounted at the outer end of a conductive pipe 21 hermetically sealed through the wall of the block 1. On the exterior of the tube the high frequency oscillations may be conducted to any suitable utilization circuit by a concentric line or any other transmission means in a manner known in the art.

In the operation of such devices a capacity exists between the cathode 8 and the face of each anode section 15. Also capacitances exist between the side walls of each of the slots 13. The inner walls of the cavities 14 constitute inductances. The anode therefore is so designed and spaced relative to the cathode that the capacitances and inductances described constitute circuits which are tuned. The construction so far described is such that these circuits are resonant at a predetermined frequency depending upon the geometry of the tube. The device is intended to operate so that each cavity 14 and its adjacent arms form a circuit tuned to the frequency at which each of the other cavities 14 and its adjacent arms oscillate.

Devices of the type described may oscillate not only in the desired mode, corresponding to the desired frequency, but may also oscillate in certain spurious modes corresponding to undesired frequencies. For example, oscillations may occur between non-adjacent arms 15 and to limit such spurious or undesired oscillations alternate arms 15 may be connected together. In the instance shown, such interconnection is effected by means of straps 22 and 23, the upper strap 22 being connected to alternate arms 15 and free from contact with the intervening arms which are provided with slots 24 through which the strap 22 may pass without contacting such intervening arms. The lower strap 23 is connected to the intervening arms and is not connected to the alternate arms, free passage therethrough being permitted by similar slots 24 in said alternate arms. This construction serves to limit the spurious oscillations in a manner more fully disclosed in my copending applications, Serial No. 465,413, filed November 13, 1942, and Serial No. 421,145, filed December 1, 1941, now Patent No. 2,417,789.

Heretofore where attempts have been made to vary the frequency at which the anode structure tends to oscillate, some tuning member disposed within the tube body adjacent the anode arms 15 has been moved toward or away from the arms in order to vary the effective capacitance of the resonant circuits. This has required some means such as a flexible diaphragm forming one wall of the tube and permitting movement of the tuning member relative to the anode arms.

In this construction, the desired tuning effect is obtained by providing conductors 25 and 26 connected respectively to the straps 22 and 23, which conductors extend outwardly through one of the slots 13 and its corresponding cavity 14 and through a conductive pipe 27. The pipe 27 is hermetically sealed within the wall of the block 1 and is closed at its outer end by a glass seal 28. The seal 28 has a tubular portion extending for a substantial distance beyond the end of the

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pipe 27, and the conductors 25 and 26 terminate in metallic strips 29 and 30 within the tubular portion of the seal 28. The metallic strips 29 and 30 constitute condenser plates which provide additional capacitance connected in the resonant circuits provided by the anode structure. This capacitance is therefore a portion of the capacitance determining the frequency at which each oscillatory circuit is resonant. In order to alter the capacitance of the oscillatory circuits, and thereby alter the frequency at which these circuits resonate, a conductive sleeve 31 constituting a tuning ring is provided surrounding a portion of the seal 28 and enclosing the plates 29 and 30. The tuning ring 31 is mounted for movement relative to the plates 29 and 30. In the instance shown in Figs. 1, 2 and 3, the sleeve is reciprocable in a direction extending longitudinally of the plates 29 and 30.

In operation, by shifting the tuning ring 31 in a longitudinal direction so that a greater or lesser portion of its surface area is opposed to the condenser plates 29 and 30, the electric field provided by the plates is altered. Accordingly the capacitance of the oscillatory circuits in which these plates are connected is altered and the frequencies at which the oscillatory circuits resonate are varied. Increases or decreases in the effective capacitance of the oscillatory circuit result, respectively, in lower or higher frequencies of the oscillations generated by the tube. The frequencies of the oscillations generated may therefore be controlled, within limits, at the will of the operator while the tube is in operation.

It will be observed that the invention provides a device in which the control of the oscillations generated is effected without mechanical motion of any element within the tube although the high voltage elements of the system remain inside of the evacuated space. By this construction the difficulties encountered where it is attempted to effect motion of some element within the tube through a flexible wall thereof are avoided. Also there is no danger of arcing which would be present if similar tuning means were brought out through glass seals and used under atmospheric conditions.

It will be apparent that the tuning sleeve may be adjusted either manually or mechanically to secure desired adjustments or variations in the frequencies of the oscillations generated. Where it is desired to vary the frequencies periodically the sleeve may be actuated at a predetermined time rate.

In the form of the invention described in the foregoing, the conductors 25 and 26 are connected to the straps 22 and 23. Alternative constructions may be used; for example, the conductors may be connected directly to adjacent arms 15 as shown in Fig. 4. In this figure there is shown a portion of a magnetron which is similar to the magnetron shown in Figs. 1, 2 and 3. In this instance the conductors 25 and 26 are connected directly to adjacent arms 15.

While there is shown in this figure a strapping means 22, it will be understood that this strap performs its usual functions and is not directly connected to one or the other of the conductors 25 and 26. The manner of connecting these conductors directly to the arms 15 is, therefore, applicable to tubes of the type which are not provided with any strapping means.

In both of the constructions so far described it has been found desirable to make the effective electrical distance L between the points of con-

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nection of conductors 25 and 26 and the center of the condenser provided by the strips 29 and 30 approximately equal to $N\lambda/2$ where λ is the length of the waves on the system and N is a small integer.

It will be understood that instead of being reciprocable, the tuning sleeve 31 may be so constructed that rotation thereof will alter the effective capacitance of the condenser. For example, the sleeve 31 may be provided with slots 32 as shown in Figs. 7 and 8 extending longitudinally thereof so that the surface area of the sleeve coacting with the condenser plates 29 and 30 may be altered by angular adjustments of the sleeve 31. This construction is particularly adapted for continuous operation to periodically vary the frequencies of the oscillations generated, the sleeve being rotated at a predetermined speed.

In both forms of the invention described in the foregoing, a pair of conductors 25 and 26 is provided, which conductors are of the same electrical length and constitute a balanced transmission line. In some instances, as for example in the construction shown in Figs. 5 and 6, the connections to the condenser plates 29 and 30 may not provide a balanced transmission line. In these figures there is shown a magnetron which is generally similar to that shown in Figs. 1, 2 and 3 except that the connections between the bridging portion 6 and the condenser plates have been modified.

In this construction one of the conductors 25 is connected to the strap 22 and extends outwardly through the free space 2 and through the conductive pipe 27 to the condenser plate 29. The pipe 27 is hermetically sealed within the wall of the block 1 and in this instance opens into the free space 2. A choke section 35 having one end connected to the pipe 27 at a point intermediate the length thereof extends parallel to and is spaced from the outer end of the pipe. The glass seal 28 is in this instance sealed to the outer end of the choke section 35. The condenser plate 30 is connected directly by the conductor 26 to the outer end of the conductive pipe 27. The length of the choke section is approximately equal to $\lambda/4$ where λ is the length of the waves on the system. As in the previously described construction the condenser plates 29 and 30 are positioned to coact with a tuning ring 31 on the exterior of the glass seal 28. The provision of a choke section 35 transforms the otherwise unbalanced transmission line resulting from this arrangement to a balanced transmission line and isolates the external part of the tube box from the high frequency of the internal oscillatory circuit.

In all the constructions illustrated the invention is applied to an electronic discharge tube of the type having a plurality of resonant cavities. It will be understood that in its broader aspects the invention is readily applicable to tubes of the type containing a single resonant cavity and the invention may be readily applied thereto by those skilled in the art from the teachings thereof.

While I have described particular embodiments of my invention, it will be apparent that various changes may be made without departing from the teachings hereof. For example, from the embodiments shown, it will be apparent to those skilled in the art that the conductors 25 and 26 may be connected in the oscillatory circuit of the cavity structure in various ways and that the invention may be applied to any tube of the type having an internal oscillatory circuit. While the

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invention has been described in conjunction with a tube for generating oscillations, it is obviously applicable to tubes for amplifying and receiving oscillations. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A tunable electron-discharge device comprising: an evacuated anode structure having a dielectric wall portion; said anode structure defining at least one cavity resonator; a pair of condenser elements connected to points adapted to be at different relative potentials in at least one such cavity resonator; said condenser elements being disposed within said anode structure, adjacent said dielectric wall portion; and means, external of said anode structure, and capacitively adjustable with respect to said condenser elements through said dielectric wall portion, for altering the capacitance between said condenser elements.

2. A tunable electron-discharge device comprising: an evacuated anode structure defining at least one cavity resonator; a hollow, dielectric member opening into the interior of said anode structure; a pair of condenser elements, disposed within said dielectric member, and connected to points adapted to be at different relative potentials in at least one such cavity resonator; and means, external of said anode structure, and capacitively adjustable with respect to said condenser elements through said dielectric member for altering the capacitance between said condenser elements.

3. A tunable electron-discharge device comprising: an evacuated anode structure defining at least one cavity resonator; a hollow, dielectric member opening into the interior of said anode structure; a pair of condenser elements, disposed within said dielectric member, and connected to points adapted to be at different relative potentials in at least one such cavity resonator; and a conducting sleeve, movably mounted exteriorly of said dielectric member, and capacitively adjustable with respect to said condenser elements through said dielectric member, for altering the capacitance between said condenser elements.

4. A tunable electron-discharge device comprising: an evacuated anode structure having a dielectric wall portion; said anode structure defining at least one cavity resonator; a pair of condenser elements connected to points adapted to be at different relative potentials in at least one such cavity resonator by a transmission line having an effective electrical length approximately equal to $N\lambda/2$, where N is a small integer and λ is the mean wave length of the oscillations adapted to be generated by said device; said condenser elements being disposed within said anode structure, adjacent said dielectric wall portion; and means, external of said anode structure, and capacitively adjustable with respect to said condenser elements through said dielectric wall portion, for altering the capacitance between said condenser elements.

5. A tunable electron-discharge device comprising: an evacuated anode structure defining at least one cavity resonator; a hollow, dielectric member opening into the interior of said anode structure; a pair of condenser elements, disposed within said dielectric member, and connected to points adapted to be at different relative potentials in at least one such cavity resonator by a transmission line having an effective electrical

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length approximately equal to $N\lambda/2$, where N is a small integer and λ is the mean wave length of the oscillations adapted to be generated by said device; and means, external of said anode structure, and capacitively adjustable with respect to condenser elements through said dielectric member, for altering the capacitance between said condenser elements.

6. A tunable electron-discharge device comprising: an evacuated anode structure defining at least one cavity resonator; a hollow, dielectric member opening into the interior of said anode structure; a pair of condenser elements, disposed within said dielectric member, and connected to points adapted to be at different relative potentials in at least one such cavity resonator by a transmission line having an effective electrical length approximately equal to $N\lambda/2$, where N is a small integer and λ is the mean wave length of the oscillations adapted to be generated by said device; and a conducting sleeve, movably mounted exteriorly of said dielectric member, and capacitively adjustable with respect to said condenser elements through said dielectric member for altering the capacitance between said condenser elements.

7. A tunable electron-discharge device comprising: an evacuated anode structure having a dielectric wall portion; said anode structure defining a plurality of cavity resonators; a pair of conducting straps alternately contacting successive points of opposite potential in said cavity resonators; a pair of condenser elements connected, respectively, to said straps; said condenser elements being disposed within said anode structure, adjacent said dielectric wall portion; and means, external of said anode structure, and capacitively adjustable with respect to said condenser elements through said dielectric wall portion, for altering the capacitance between said condenser elements.

8. A tunable electron-discharge device comprising: an evacuated anode structure defining a plurality of cavity resonators; a pair of conducting straps alternately contacting successive points of opposite potential in said cavity resonators; a hollow, dielectric member opening into the interior of said anode structure; a pair of

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condenser elements, disposed within said dielectric member, and connected to one of said straps and said anode structure by an unbalanced transmission line; a choke sleeve surrounding said transmission line to balance the same; and means, external of said anode structure, and capacitively adjustable with respect to said condenser elements through said dielectric wall portion, for altering the capacitance between said condenser elements.

9. A tunable electron-discharge device comprising: an evacuated anode structure including a cavity resonator; conducting members, connected to points adapted to be at different relative potentials within said cavity resonator, and extending exteriorly of said cavity resonator; condenser elements connected to said conducting members exteriorly of said cavity resonator; and means, adjacent said condenser elements and capacitively adjustable with respect thereto, for altering the capacitance therebetween.

10. A tunable electron-discharge device comprising: an evacuated anode structure including a cavity resonator; conducting members, connected to points adapted to be at different relative potentials within said cavity resonator, and extending exteriorly of said cavity resonator; condenser elements connected to said conducting members exteriorly of said cavity resonator; and a conducting sleeve, spaced from and surrounding said condenser elements, and capacitively adjustable with respect thereto, for altering the capacitance therebetween.

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