KLYSTRON OSCILLATOR AND METHOD OF ADJUSTING SAME

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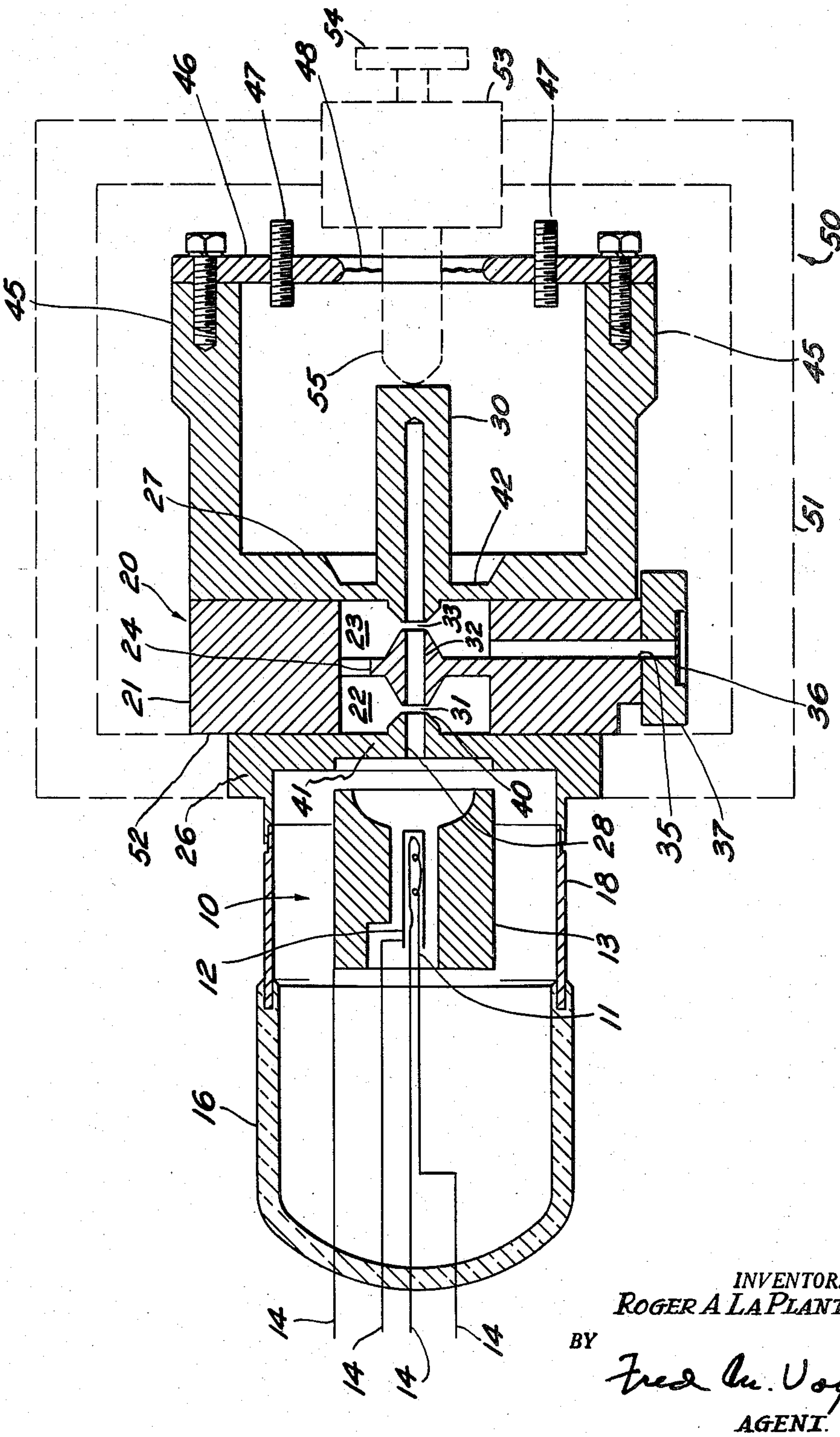

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KLYSTRON OSCILLATOR AND METHOD OF ADJUSTING SAME

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1 Claim. (Cl. 315—5.53)

This invention relates to klystron oscillators, and, more particularly, to klystron oscillators of the two-cavity type and to methods of adjusting the same.

A known klystron oscillator of the two-cavity type employs flexible diaphragms associated with each of the cavities for both causing the tube to oscillate at its optimum point, and for adjusting the frequency of said oscillations over a predetermined range. A flexible diaphragm forms one wall of each cavity and supports one side of each interaction space. The diaphragm is maintained in position by a tuning mechanism. Tubes of this type have been found to be excessively nosy during normal operation. Extensive research into the cause of the noise has led to the conclusion that the principal source of noise within a two-cavity klystron oscillator is microphonism, which has been found to derive from the flexible diaphragm type of construction.

One object of the invention is the provision of a two-cavity klystron oscillator without the conventional type of flexible diaphragm structure.

A further object of the invention is a klystron oscillator of the two-cavity type adapted to operate at a fixed frequency.

Still a further object of the invention is a method for adjusting a two-cavity klystron oscillator to cause the latter to oscillate at a fixed frequency.

Another object of the invention is a method for adjusting a klystron oscillator employing a mechanism which may be removed from the tube.

These and further objects of the invention will be best understood from the following description.

The klystron oscillator of the invention includes an electron gun at one end of an evacuated tube, a collector at the other end, and a pair of coupled resonant cavities disposed therebetween and through which an electron beam produced by the gun is projected. In the ordinary way, the first or input cavity contains an interaction gap modulating the beam so that it is velocity modulated or bunched during its passage through a subsequently-arranged drift tube. Thereafter, it passes through the interaction gap of the second or output cavity, which extracts energy from the bunched beam and delivers it to an external circuit.

The klystron of the invention is characterized by the absence of flexible diaphragms. The input cavity is defined by completely rigid, conductive walls preventing any appreciable change whatsoever in the interaction gap dimensions. Thus, the resonant frequency of the input cavity is completely fixed by its predetermined dimensions. The output cavity, on the other hand, has an externally unsupported, solid, metal, relatively rigid wall by which its interaction gap may be varied enabling a change in the resonant frequency of the second cavity. By the term "relatively rigid," I mean that the stiffness of this wall of the output cavity, unsupported externally, is sufficiently large to prevent any appreciable change in the output interaction gap due to vibrations encountered during the normal operation of the tube, but is low

enough to be capable of being slightly deformed by the application of a large external force.

The method of adjusting the two-cavity klystron tube in accordance with the invention is as follows. The operating frequency of the tube is fixed by the application, which controls the dimensions of the completely rigid, input cavity. In order to obtain oscillations with such a tube, the resonant frequency of the second or output cavity must have a predetermined value correlated to that of the input cavity. In manufacturing the tube, it is impossible to produce the exact dimensions required of the output cavity, inasmuch as these are not even known; thus, the interaction gap of the output cavity is made oversize. That is to say, it is given dimensions which are at least 10% and preferably about 50% higher than those probably required of that cavity for proper operation. For example, for a required interaction gap of about .020 inch, the gap is preferably initially constructed with a spacing of about .030 inch. As mentioned hereinbefore, one wall of the output cavity, the one defining the interaction gap therein, is relatively rigid, though constructed not of the ordinary thin flexible diaphragm material, but of thick solid metal. The correct operating potentials are applied to the tube depending on the desired mode of operation. Thereafter, pressure is slowly applied to the relatively rigid wall along the axis of the tube tending to push it inward and thus reduce the spacing of the interaction gap while the operator observes a meter coupled to the output of the tube. It will thus be observed that the tube suddenly breaks into oscillation at a critical spacing and the output power produced thereby slowly increased as the pushing continues. At this point, the pushing has been extended to a point beyond the elastic limit of the wall material so that a permanent deformation of the wall has been produced. That is to say, the force applied and displacement obtained is sufficiently great to strain the relatively rigid cavity wall beyond the elastic limit of the wall material and permanently set it in a new position. When the position of maximum output is attained, the pressure is released and the pressure-applying apparatus removed from the tube. The deformed wall is now permanently set very close to the exact position required for optimum operation. Now, whenever the tube is excited, it will always produce the exact same mode and frequency of operation with maximum power. Further, all microphonism previously attributed to the construction of the cavities has been eliminated.

Another advantage flowing from the use of a relatively-rigid wall which may be permanently set in a desired position is in the fact that the removal of the adjusting or pressing force will cause the relatively-rigid wall to relax or recede to an intermediate position. The actual amount of recovery will depend upon the elasticity of the wall material and the configuration of the deformed wall. This recovery or relaxation phenomena is a distinct advantage in that it enables displacement of the wall past the correct or desired position for optimum adjustment without risk of over-deformation. In particular, the observer can now displace the wall past the position of maximum power, i. e., the peak on the power curve, and then, by releasing the pressing force, allow the wall to move slightly backward, i. e., recover, to the exact position desired. Experience will dictate how far past the desired point need the wall be displaced to attain the correct position upon recovery. Thereafter, the pressure mechanism is removed and the tube is ready for use. Since the relatively rigid, deformed wall has sufficient stiffness to withstand all vibrations occurring during operation of the tube, no further microphonism attributable to the cavity structure will be observed.

The invention will now be described in connection with the accompanying drawing in which the sole figure shows a klystron oscillator with the mechanism for adjusting the same in accordance with the invention.

Referring now to the drawing, there is illustrated a cross-sectional view of a two-cavity klystron power oscillator. The klystron comprises an electron gun 10 including a heating filament 11, an electron-emissive cathode 12, preferably of the dispenser type, and a focussing electrode 13. Connected to these three electrodes are the usual terminal connections 14 which are sealed through an insulating wall 16, e. g., glass, of a surrounding enclosure. By means of a Kovar ring 18, the glass enclosure 16 is vacuum-tight sealed to the anode or resonant structure 20 of the tube.

The resonant structure 20 comprises a solid copper body 21 in which are machined a pair of resonant cavities 22, 23. The cavities 22, 23 communicate by way of a coupling aperture 24. The front side of the block 21 is closed off by a copper plate 26, and the rear side of the block 21 is also closed off by another copper plate 27. Through the centers of the plates 26 and 27 and the block 21 passes an aperture 28 communicating with each of the cavities 22, 23 and serving as a path for an electron beam produced by the gun 10. The electron beam is collected by a recessed portion of the plate 27, called the collector electrode 30. The electron beam passing through the aperture 28 communicates with the input cavity 22 via an interaction gap 31. In the usual way, oscillations present in the cavity 22 velocity modulate the beam as it passes across the gap 31. During its subsequent passage through a drift tube 32, the beam becomes bunched in a manner well known to the art, after which it crosses an interaction gap 33 communicating with the second or output cavity 23 producing oscillations therein. A portion of the energy in the output cavity is returned by way of the coupling aperture 24 to the input cavity to maintain the oscillations therein. A transformer section 35, in this case a machined rectangular-shaped aperture, communicates with the output cavity 33 and serves as the coupling means for extracting energy therefrom. This aperture is vacuum-tight sealed off by a mica washer 36 powderglass sealed to a chrome-iron member 37, which in turn is secured to the body 21. The member 37 is adapted to have a wave-guide section (not shown) secured thereto for conveying away the energy extracted from the output cavity. The interior of the tube is evacuated in the conventional way.

As is well known in the art, tuning of two-cavity klystrons is generally effected by changing the length of the interaction gaps in the input and output cavities, thus changing the capacitance and the resonant frequency of the associated cavity. This has been accomplished in the past by mounting the front wall portion 40 of the plate 26, which controls the input interaction gap 31, and the collector electrode 30, which controls the output interaction gap 33, on flexible diaphragms which are readily adjustable. By means of elaborate tuning mechanisms for holding the flexible diaphragms in a desired position, the flexible diaphragms may be adjusted and the klystron tuned.

The present invention provides a klystron construction in which the flexible diaphragms are completely eliminated. Thus, the portion 40 defining the input interaction gap 31 is mounted on a flat, solid, copper wall portion 41 which is completely rigid and immovable. Hence, the resonant frequency of the input cavity is unalterably fixed at a predetermined value when the tube is completed. However, in order to produce oscillations, the output cavity must be adjusted to a predetermined resonant frequency correlated to that of the input cavity. This is accomplished by mounting the collector on a copper wall portion 42 of the plate 27 which is of reduced thickness relative to that of the remainder of that plate 27 and has a value enabling the wall to be slightly deformed upon the application of an external force. The reduced thickness portion 42 enables more ready displacement of the desired portion of the plate without fear of destroying the solder seal between the plate 27 and the block 21. Of course, while the portion 42 is displaceable by an external force, as noted before, it is sufficiently stiff to resist all vibrations occurring during normal operation of the tube. The displacement of the wall will vary the length of the output interaction gap 33 and thus the resonant frequency of the output cavity 23.

To ensure the desired operation, the interaction gap of the output cavity 23 is made oversize during the manufacture, thereby requiring an inward displacement of the deformable wall 42 to achieve the correct resonant frequency. To further ensure that the final position of the deformable wall is precisely that required, the displacing of the wall occurs while the desired operating potentials are applied to the tube. Then, while the tube is excited the wall is slowly pushed inwardly until slightly past the point at which the desired power output is achieved, after which the pushing force is released enabling the wall to spring slightly back to the exact desired position. The wall is permanently set in this latter new position.

Since displacement of the wall occurs while the tube is excited, provision must be made to effect the displacement while continuing the conventional water cooling of the anode system. To that end, the rear plate 27 has a rearwardly-extending cylindrical portion 45 to the end of which is secured a water-tight cover plate 46. The cover plate 46 is provided with inlet and outlet water couplings 47 by means of which cooling water may be circulated around the collector 30 to cool the latter.

The displacing of force-applying mechanism 50 is shown in phantom in the drawing surrounding the anode system. It comprises, simply, a strong, rigid, supporting housing 51 which embraces the front part of the anode system along a shoulder 52. The other or rear end of the housing 51 supports a reducing gear train 53 (shown diagrammatically) to one end of which is secured a rotatable, control knob 54, and to the other end of which is secured a drive screw 55. The gear train had, for example, a gear reduction ratio of about 25:1, and the screw had a lead of .050 inch per revolution. Rotation of the knob 54 in one direction causes the drive screw 55 to advance forward and engage the rear of the collector 30, after which further rotation in the same direction will cause the wall 42 supporting the latter to be slightly deformed enabling a reduction in the length of the interaction gap 33. To maintain the system water-tight, the drive screw is secured in a water-tight manner to the cover plate 46 by means of a flexible diaphragm 48 allowing displacement of the drive screw 55.

As indicated previously, the wall portion defining the output interaction gap, in this case the collector 30 and wall portion 42, are moved inwardly while the tube has applied to it the desired potentials. As has also been noted, the knob is rotated until the wall is pushed inwardly always past the point of desired operation, which is usually the point of peak power output, to allow the natural recovery of the wall 42 to carry it backward to precisely the exact position. The original dimensions of the output cavity are made sufficiently oversize so that the wall 42 is always displaced beyond the elastic limit of the material of which it is constituted and is thus permanently set in its final position. Thereafter, the force is released by rotating the knob 54 in the opposite direction, the operating potentials removed from the tube, the mechanism 50 completely removed from the tube, and the cover plate 46 replaced by a similar cover plate (not shown) without the diaphragm 48. Now, whenever operating potentials are applied to the tube of the invention, it will always oscillate at the exact same frequency with the exact same power output without any further adjustments being required. The thus-produced tube may be considered essentially a fixed-frequency oscillator. However, there is one exception, namely, by keeping the dimensions of the cavities constant, application of different potentials may cause the tube to oscillate in a different mode and thus at a slightly different frequency.

The thickness of the wall portion **42** by which the desired results are achieved depends entirely on the mass of the collector **30** which it supports, its own chemical constitution, the diameter of the narrowed portion **42** or of the cavity **23** and that of the collector **30**, and the desired amount of rigidity required for the particular application. As one typical example, for a copper wall **42** having a diameter of about ⅝ inch and a copper collector **30** having a length of ⅞ inch, an O. D. of 5⁄16 inch and an I. D. of .085 inch, a suitable thickness is about 5⁄64 inch. However, these values are not to be considered limiting since the important requirements are that the wall may be slightly deformed in an axial direction and that it will be permanently set in its new position after deformation so that the tuning mechanism may be removed from the tube. This offers the additional advantage that no outside means are needed to fix or maintain the desired dimensions of the cavities. Moreover, a single tuning mechanism, since it need not remain attached to the tube, may serve to adjust or tune a plurality of klystron tubes.

While we have described our invention in connection with specific embodiments and applications, other modifications thereof will be readily apparent to those skilled

in this art without departing from the spirit and scope of the invention as defined in the appended claim.

What is claimed is:

A fixed-frequency velocity-modulated electron discharge device comprising means for generating a beam of electrons, an evacuated envelope having relatively rigid and non-deformable conductive wall portions defining at least two interconnected cavities of relatively fixed dimensions into which said electron beam is projected, one of said wall portions being of reduced thickness for initially deforming the same whereby the dimensions of said cavities are initially adjusted for tuning one of said cavities, and a collector electrode adjacent one of said cavities for collecting said electron beam, after passing through said cavities.

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