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ELECTRON DISCHARGE DEVICE

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Fig. 1

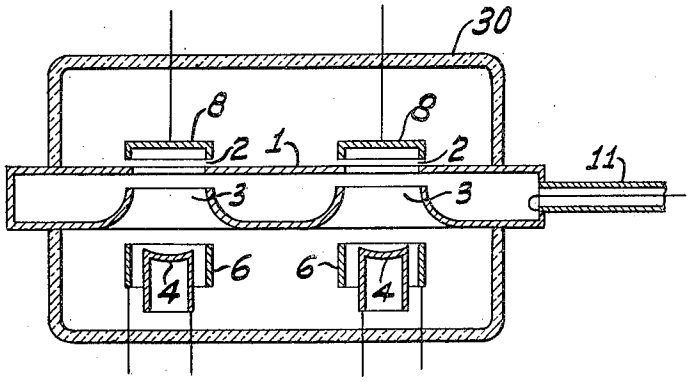
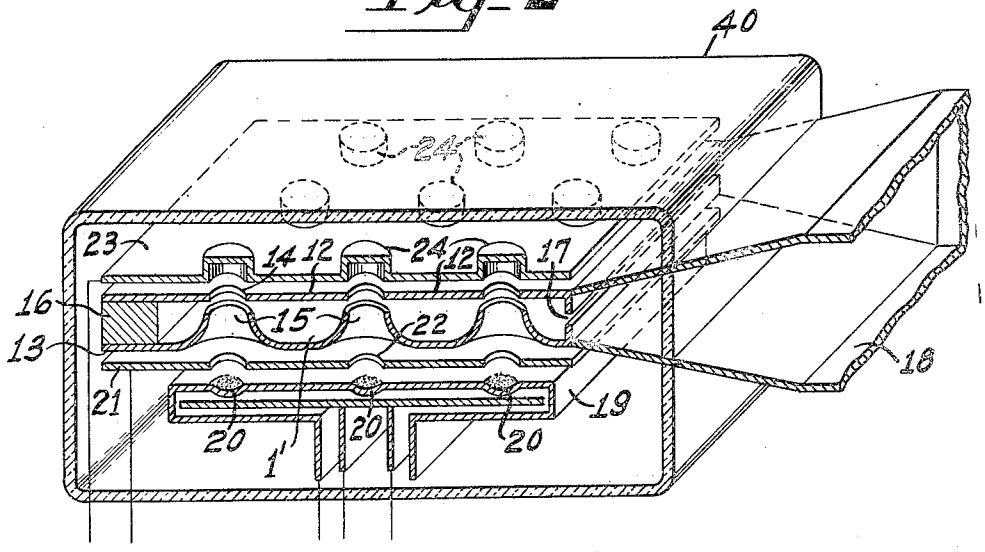


Fig. 2



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ELECTRON DISCHARGE DEVICE

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4 Claims. (Cl. 315—6)

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This invention relates to electron discharge devices employing hollow resonators. Electron discharge devices employing resonators have been proposed for a variety of purposes, such as amplifiers of high-frequency oscillations, generators of self-maintained oscillations and mixers for high-frequency oscillations, the resonators in such devices serving to impart velocity-modulation to a beam of electrons directed through one or more of the resonators employed in the devices. Electron discharge devices employing hollow resonators have also been proposed for other purposes.

Whilst it is comparatively easy to construct hollow resonators for operation at about 3000 megacycles per second it becomes progressively more difficult to construct resonators for operation at higher frequencies, particularly above 20,000 megacycles per second. It will be realised that the dimensions of the hollow resonators employed determine in the main the resonant frequencies of the latter and as the frequency of operation is increased the dimensions of the resonators become progressively smaller for the same mode of oscillation. A hollow resonator designed for fundamental resonance at about 20,000 megacycles per second may, for example, have physical dimensions of the order of only 5 millimeters in diameter and 2 millimeters deep. It will be appreciated that with these small dimensions the practical construction of resonators becomes difficult. Furthermore, the efficiency of the resonators becomes less as the dimensions decrease, firstly, since the shunt impedance across the gap of the resonator decreases as it is scaled down to resonate at greater frequency due to skin effect and greater losses at the joints between the various parts of the resonator, and secondly, because the smaller the resonator the smaller will be the current which can be passed through the apertures in the resonators.

The object of the present invention is to provide an improved electron discharge device with a view to overcoming or reducing these difficulties.

According to the invention, electron discharge apparatus is provided comprising a hollow resonator having a plurality of pairs of opposed apertures, means for projecting a beam of electrons through each of said pairs of apertures, said pairs of apertures being so spaced that in operation and when said resonator is excited at a harmonic of its fundamental frequency said beams of electrons pass through said resonator

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at or near different voltage anti-nodes of the oscillatory field therein.

The invention also provides a novel electron discharge device employing a hollow resonator and having means for passing a plurality of electron beams through pairs of opposed apertures in said resonator.

In order that the said invention may be clearly understood and readily carried into effect, it will now be more fully described with reference to the accompanying drawings in which—

Figure 1 is a diagrammatic cross-sectional view of an electron discharge device constructed according to one form of the invention, and

Figure 2 is a perspective view partly broken away illustrating the preferred form of the invention.

As shown in Figure 1, the electron discharge device comprises a hollow resonator 1 the walls of which are provided, as shown, with pairs of opposed apertures 2 and 3 the latter being formed at the ends of trumpet shaped projections. An electron beam is projected through each of the pairs of apertures 2 and 3 from cathodes 4 which are associated with cathode shields 6. The device shown in Figure 1 is intended to operate as a generator of self-maintained oscillations and, accordingly, after electron beams from the cathodes 4 have passed through their respective apertures 2 and 3, they are reflected back through these apertures by reflecting electrodes 8 which are maintained in operation at suitable potentials. Oscillations are set up in operation in the resonator in a harmonic mode such that different voltage anti-nodes occur at or near the paths of the electron beams through the resonator. The oscillations generated can be abstracted from the resonator by means of a coupling loop 10 and concentric line 11. The electron discharge paths of the device are enclosed by an evacuated envelope 30.

The device shown in Figure 1 can be regarded as a pair of oscillators having hollow resonators operating in a fundamental mode in opposite phase. Thus, if the resonator 1 were to be divided into two similar resonators by inserting a conducting wall between the mid-points of the opposed centre portions of said resonator, it would become a pair of similar resonators operating in a fundamental mode. It will, therefore, be seen that by means of the invention the size of the resonator for the same operating frequency has been substantially doubled. The electron current has also been doubled but the resonator losses have not increased to a similar extent be-

cause the resonator according to the invention has less surface than have the two fundamental resonators already mentioned.

The construction shown in Figure 1 is not advantageous from the constructional point of view because the individual cathodes and cathode shields and the reflecting electrodes are required to be individually aligned and, accordingly, it is preferred to employ the construction shown in Figure 2 of the drawings. The hollow resonator 1' comprises a pair of plates 12 and 13, the plate 12 having a plurality of apertures 14 therein, whilst the plate 13 also has a plurality of apertures 15 formed at the ends of the trumpet-shaped projections facing apertures 14 so that nine pairs of opposed apertures are provided. The edges of the plates 12 and 13 are joined by a frame 16 which serves to close the resonator except at its right-hand edge where a slot 17 is formed through which oscillations set up in operation in said resonator can be fed to a waveguide indicated at 18. A single flat cathode 19 is provided the surface of which facing the resonator is covered with electron-emitting material at least in the areas facing the apertures 15, or, alternatively, said surface may be provided with a plurality of depressions 20 which are provided with electron-emitting material, said depressions 20 being aligned with the apertures 14 and 15. A cathode shield 21 is provided, this shield comprising one or more plates having a plurality of apertures 22 which may have annular lips, said apertures 22 being aligned with the apertures 14 and 15. The device shown in Figure 2 is also intended to function as a generator of self-maintained oscillations and, accordingly, the reflecting electrode which serves to reflect the electrons back into the resonator comprises a plate 23 provided with a plurality of recesses 24 which are aligned with the apertures 14, 15 and 22. An evacuated envelope 40 surrounds the device. The construction shown in Figure 2 has the advantage over the arrangement shown in Figure 1 in that alignment of the various elements of the device is facilitated since the cathode 19, cathode shield 21, plates 12 and 13 and plate 23 can be aligned in a single operation as, for example, by the provision of holes or other locating members formed near the edges of said elements.

Although the invention has been described above as applied to an oscillator of the reflection

type, it will be understood that the invention is not limited thereto, since it can be applied to other forms of devices employing hollow resonators, such as amplifiers, mixers, modulating devices, gas switches and the like and to discharge devices which employ a plurality of resonators arranged in succession along the path of an electron beam.

What I claim is:

1. An electron discharge device including an evacuated envelope containing a cavity resonator in the form of a rectangular box, two opposed walls of said box having a plurality of pairs of aligned apertures, each pair of aligned apertures being located at a voltage anti-node point of a harmonic of the fundamental oscillating field of said resonator, and means adjacent said resonator for projecting a beam of electrons through each pair of aligned apertures, the size of said resonator being substantially larger than a single-beam resonator for the same operating frequency.

2. An electron discharge device according to claim 1, further including an electrode disposed in the path of the electron beams and beyond said resonator for repelling the electrons back through said resonator.

3. An electron discharge device according to claim 1, wherein said means for projecting a beam of electrons through each pair of aligned apertures comprises a single flat cathode and a cathode shield plate having a plurality of apertures aligned with said resonator apertures.

4. An electron discharge device according to claim 2, including means coupled to said cavity resonator for extracting energy therefrom.

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