Nov. 26, 1946. J. H. FREMLIN 2,411,535

HIGH FREQUENCY ELECTRON DISCHARGE APPARATUS

Filed June 2, 1942

Fig. 1

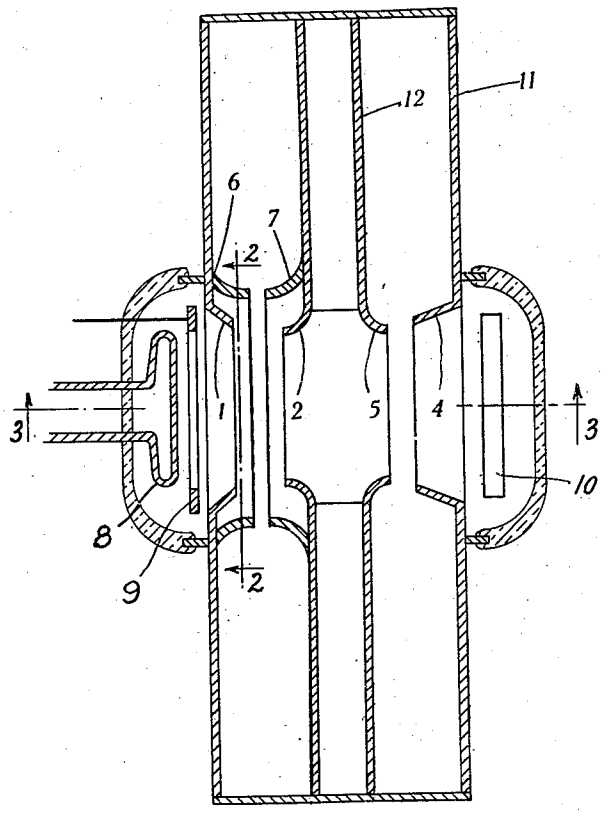


Fig. 2

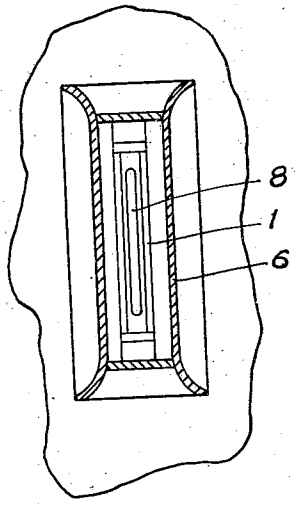
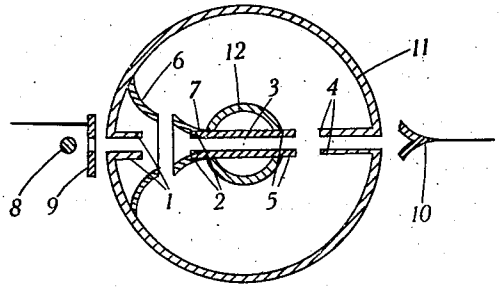


Fig. 3



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HIGH-FREQUENCY ELECTRON DISCHARGE APPARATUS

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Application June 2, 1942, Serial No. 445,505
In Great Britain August 2, 1940

6 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge apparatus for operation at very high frequencies and particularly to such apparatus of the electron-velocity modulation type.

Electron discharge tubes working by means of velocity modulation usually suffer from one of two practical disadvantages.

Firstly, they may embody two separate resonant circuits, loosely coupled together, or secondly, they may comprise a single resonator or two resonators very closely coupled together. In the first case it is possible to use a low amplitude velocity modulation and hence to avoid the loss of efficiency produced by a wide velocity variation in the modulated beam, but it is necessary that the separate circuits should be very accurately tuned to each other. This, of course, leads to serious practical difficulties in sealed-off tubes.

In the second case the tuning presents no difficulty but on account of the close coupling the modulating and working voltage amplitudes are very close together and hence there is a wide velocity spread in the modulated beam and consequent loss of efficiency.

By the present invention the advantages of both types may be obtained simultaneously.

According to the invention, in an electron discharge apparatus comprising a single resonator or a pair of resonators and electrodes for directing an electron beam through two successive gaps therein so that the electrons are modulated in velocity in the first gap and yield energy at the second gap for the maintenance of oscillations in the resonator or resonators, shielding means is associated with the first gap for the purpose of reducing the intensity of the oscillating field therein.

According to another aspect of the invention, in an electron discharge apparatus of the electron-velocity modulated type comprising as a resonator a short length of concentric conductor line having aligned diametric slots or apertures in the outer and inner tubular conductor members forming successive gaps which are adapted to be traversed in turn by an electron beam, the first or modulating gap is partially screened by a pair of shields which are respectively attached to or form part of the outer and inner conductor members.

If the effect of the electromagnetic oscillation, for example, is halved the length of the drift space can be nearly doubled for the same bunching effect and, if losses of electrons to the walls are not seriously increased a very considerable gain in efficiency will result.

In the accompanying drawing which illustrates one embodiment of the invention, Fig. 1 is a vertical section of a tube according to the invention, Fig. 2 is a section taken on the line 2—2 of Fig. 1, and Fig. 3 is a horizontal section through the apparatus taken on the line 3—3 of Fig. 1.

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In the drawing the invention shown as applied to an oscillator tube of the kind described in my United States Patent No. 2,320,860, issued June 1, 1943, in which the resonator comprises a short length of concentric line consisting of conductive cylinders 11 and 12. Fins 1 and 2 form the first or modulating gap in which the beam is velocity modulated. Space 3 is the drift space wherein the electron beam is bunched. Fins 4 and 5 limit the working gap where energy is extracted from the bunched beam. 8 is a cathode and 9 is a slotted electrode which may serve as a modulating grid. 10 is a collector anode. In the tube described in the patent referred to, the same high frequency potential difference exists across both gaps, viz. the modulating gap and the working gap. According to the present invention, the modulating gap between fins 1 and 2 is partially screened by a pair of rectangular section shields 6 and 7 which are respectively attached to or form part of the tubes 11 and 12 which project beyond the ends of the fins 1, 2 but leave a free path for the electron beam.

According to the properties of electrical apparatus adapted for use at very high frequencies the main displacement current will flow across the capacity between 6 and 7 and little current will flow along the inside of these screens to the fins 1 and 2. The effective oscillating field in the gap 1—2 is then less than would be the case in the absence of the screens 6 and 7 for a given amplitude across the working gap 4—5, and depends, among other things, upon the capacity between 1 and 2, the capacity between 1 and 6 and that between 2 and 7. As before, the operating direct voltage must for oscillation be of such a value that the transit time of the electrons in the drift space 3 is

$$\frac{4n+1}{4}$$

cycles, since the phase relations of the two gaps are to a first approximation unchanged by the existence of the screens. Whereas, however, in the unshielded case the optimum value for n is 1, according to the present method the optimum value of n may be 2, 3 or any desired integral value with a consequent increase in efficiency. It will usually be found that the best value for n is 2 or 3 as greater values will begin to lead to electron losses of a serious nature and the advantage to be

gained by an increase of n from 3 to 4 is extremely small compared with that gained by the increase from 1 to 2.

It is, of course, clear that the invention could equally well be applied to circular beams or to closely coupled circuits of any form as well as to the concentric line resonator which has been chosen purely as an example. The invention consists in the principle of shielding the first gap rather than to the exact method used. This might well be done by replacing the fins 1, 2 and the screens 6, 7 by a pair of solid structures of suitable shape and which may be more conveniently constructed than the separate fins and screens.

What is claimed is:

1. An electron discharge apparatus comprising cavity resonator means having a first gap for modulating the velocity of electrons and a second gap for yielding energy to the resonator means, means for generating an electron beam and positioned for directing it through said gaps and to said gaps and screening means applied to the first gap for reducing the intensity of the oscillating field therein.

2. An electron discharge apparatus for operation at high frequencies comprising cavity resonator means provided with a first gap for modulating electron velocity and a second gap aligned with said first gap, means for generating an electron beam and positioned for directing it through said gaps, and metallic shielding means surrounding said first gap and electrically connected to said resonator means.

3. An electron discharge apparatus for operation at high frequencies comprising cavity resonator means the walls of which are provided with slots forming two aligned gaps of which one serves to modulate electron velocity and the other to yield energy to the resonator, means for generating an electron beam and positioned for directing it through said gaps, fins attached to the edges of slots at each end of the modulating gap defining the length of said modulating gap, and two metallic shields respectively surrounding and spaced from the fins at each end of the modulating gap for screening said gap.

4. Electron discharge apparatus of the electron velocity modulated type comprising resonator means including a short length of concentric conductor line comprising outer and inner tubular conductor members, diametric aligned slots in the said outer and inner conductor members having edges defining first and second gaps, means for generating an electron beam and positioned for directing it through said slots and across said gaps, and metallic shielding means surrounding said first gap and electrically connected to said resonator means.

5. Electron discharge apparatus of the electron velocity modulated type comprising resonator means including a short length of concentric conductor line comprising outer and inner tubular conductor members, diametric aligned slots in the said outer and inner conductor members having edges defining first and second gaps, means for generating an electron beam and positioned for directing it through said slots and across said gaps, and two metallic shielding members surrounding said first gap and respectively attached to said outer and inner tubular conductor members.

6. Electron discharge apparatus of the electron velocity modulated type comprising resonator means including a short length of concentric conductor line comprising outer and inner tubular conductor members, diametric aligned slots in the said outer and inner conductor members forming first and second gaps, means for generating an electron beam and positioned for directing it through said slots and across said gaps, fins attached to the edges of the slots forming said first gap for defining the effective length of said first gap, and shielding members surrounding and spaced from said fins and projecting beyond the ends of said fins into the space between said outer and inner tubular conductor members.

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