Fig.1.

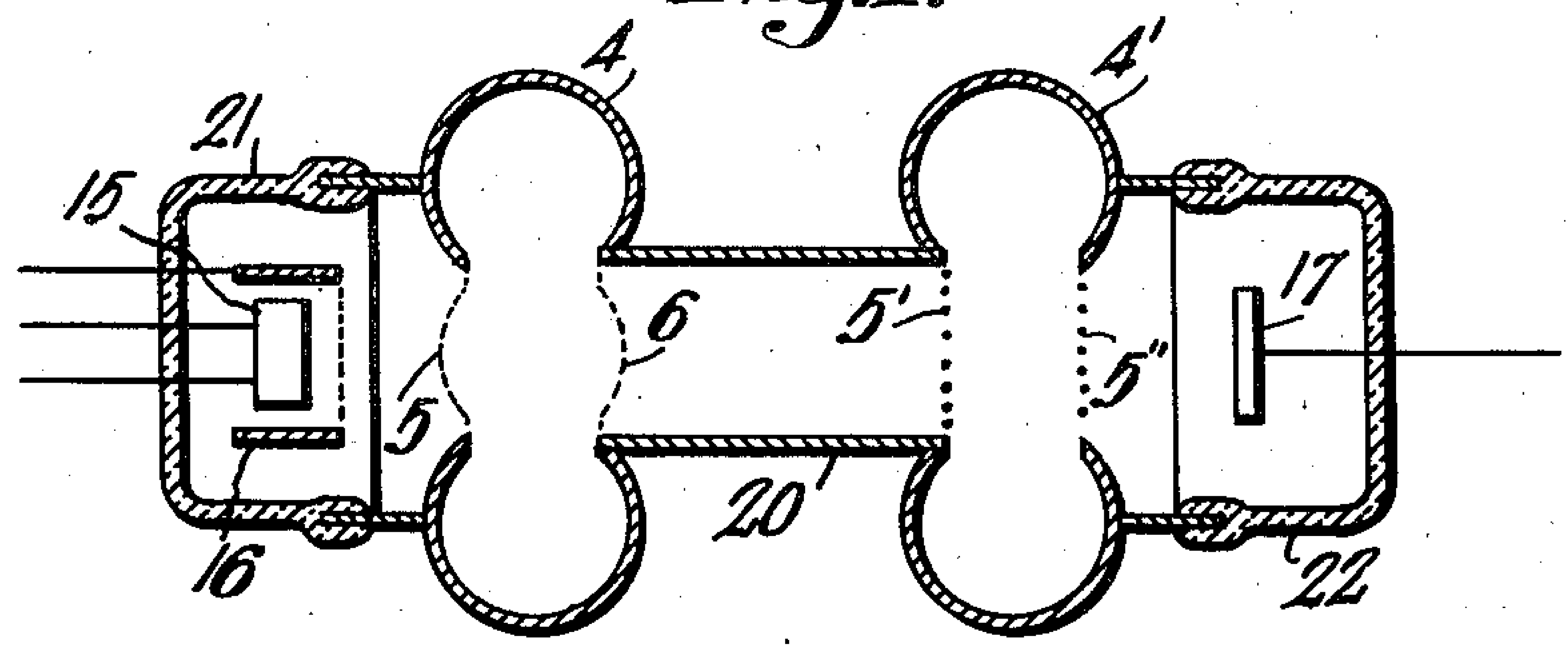


Fig.2.

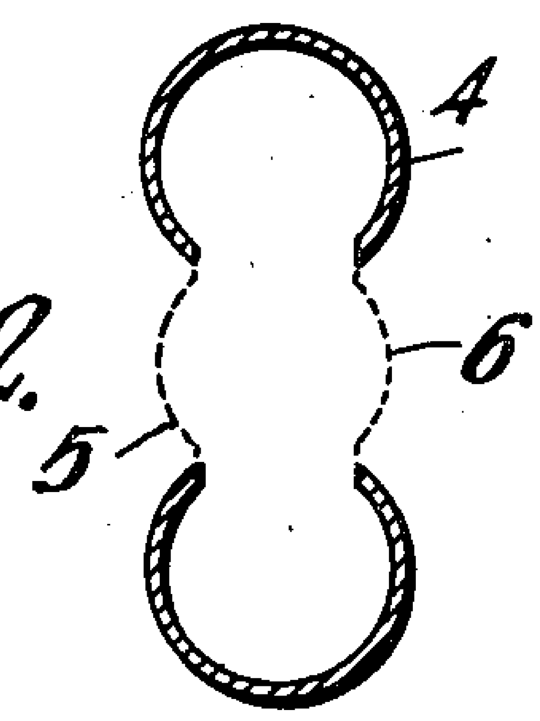


Fig.3.

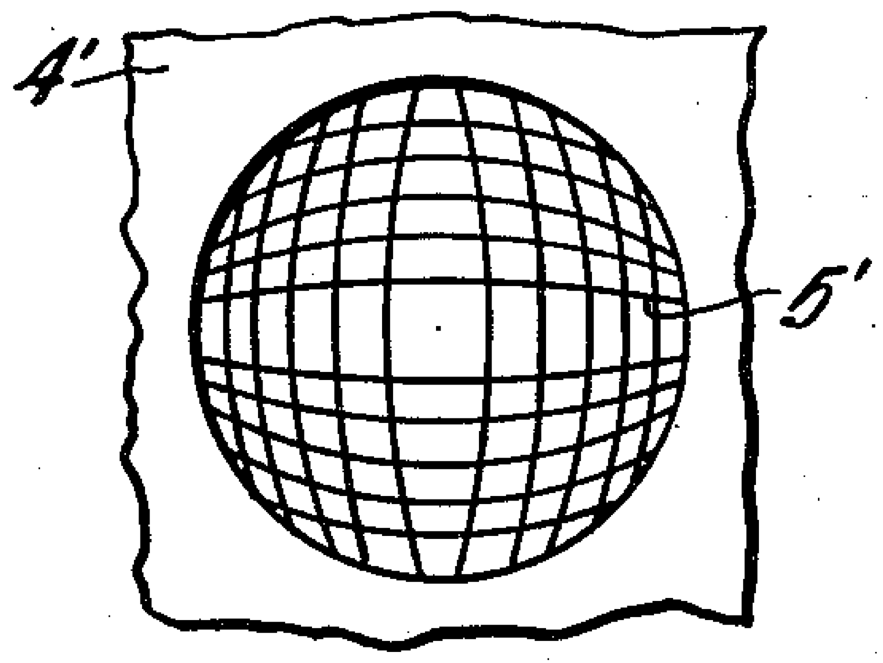
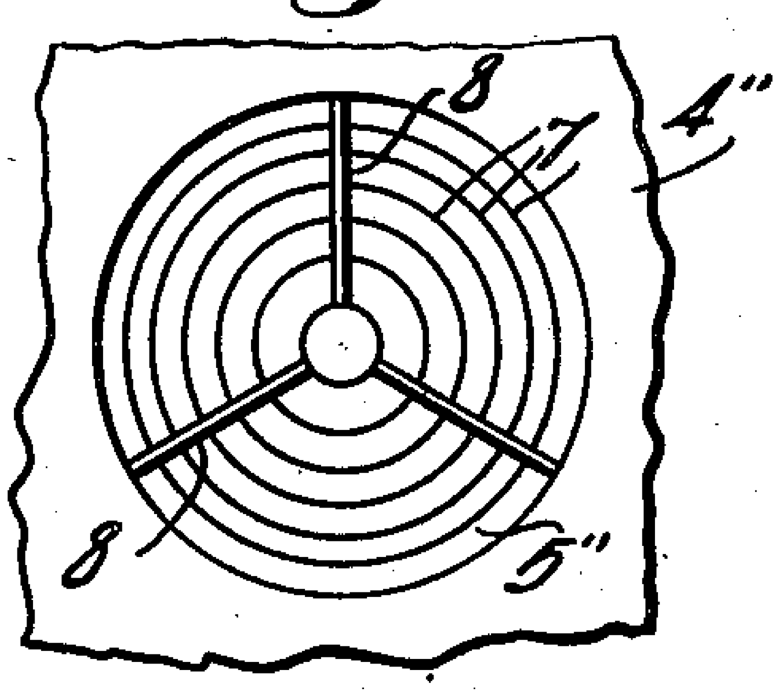


Fig.4.



INVENTORS
Albert Frederick Pearce
& Norman Charles Barford
BY H. S. Grover
ATTORNEY

Patented July 6, 1948 2,444,749

UNITED STATES PATENT OFFICE

2,444,749

ELECTRON DISCHARGE DEVICE UTILIZING CAVITY RESONATORS

Albert Frederick Pearce, Hampton Hill, and Norman Charles Barford, Hayes, England, assignors to Electric & Musical Industries Limited, Hayes, Middlesex, England, a company of Great Britain

Application September 19, 1945, Serial No. 617,334
In Great Britain August 11, 1942

Section 1, Public Law 690, August 8, 1946
Patent expires August 11, 1962

2 Claims. (Cl. 315—6)

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This invention relates to electron discharge devices embodying hollow resonators, such devices being suitable for use as generators of high frequency oscillations, mixers or amplifiers.

The resonator in some cases is of toroidal form and is provided with a pair of oppositely disposed circular apertures providing a gap through which an electron beam can be passed so as to become velocity modulated by an oscillatory field existing within the resonator. In some resonators the apertures therein are provided with grids in the form of fine mesh or in the form of thin bars for the purpose of effecting a close coupling of the electron beam with the oscillatory field within the resonator and for the purpose of preventing excessive spread of the oscillatory field beyond the apertures. The oscillatory field, in general, in such resonators sets up a voltage antinode at the center of each aperture and a voltage node at some point between the center of each aperture and the periphery of the resonator. If the oscillatory field oscillates at the fundamental frequency of the resonator the voltage node will be situated at the periphery of the resonator. If the diameter of the apertures is large, i. e., it constitutes a substantial fraction of the diameter of the resonator, it follows that the peak voltage between the grids at the periphery of the apertures will have some value which is substantially different from the value of the voltage antinode. Consequently, when an electron beam passes through the gap the axial electrons will receive a greater velocity modulation than the marginal ones, which is undesirable and may lead to inefficiency. Similar considerations arise in cases where instead of circular apertures and circularly symmetrical resonators, large apertures and resonators of other shapes are employed.

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

According to the present invention there is provided an electron discharge device embodying a hollow resonator having a pair of large apertures provided with grids wherein the spacing of the grids, or the sizes of the spaces between grid wires in one or both of the grids are so adjusted that the transit time of the axial electrons when passing through the oscillatory field at the gap is increased compared with the transit time of the marginal electrons so that the degree of velocity modulation imparted to the axial and marginal electrons is made more nearly the same.

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The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a longitudinal section of an electron discharge device utilizing resonators made according to my invention, Figure 2 is a cross-sectional view of one of the resonators in accordance with one form of the invention and shown in Figure 1 and in which the spacing of the grids is adjusted, Figure 3 is a view of a portion of a resonator shown in Figure 1 and illustrating a grid in which the size of the meshes varies over the area of the grid, and Figure 4 is a view of a portion of a resonator shown in Figure 1 and illustrating a further embodiment of the invention as applied to grids in the form of thin bars.

In Figure 1 there is shown a longitudinal section of an electron discharge device and associated resonators made in accordance with my invention. The type of device shown employs a pair of resonators in a manner now well-known and in which the electrons of the beam are velocity modulated by means of the first resonator and the energy extracted from the modulated beam by the second resonator.

The device includes an indirectly heated cathode 15 surrounded by a beam forming grid electrode 16, which may be used to density modulate the beam if desired. The electrons are directed toward a collector 17 at the other end of the electron discharge device. Positioned between the cathode and collector are a pair of successively positioned resonators 4 and 4'. The resonator 4 is provided with large apertures registering with the beam and having grids 5 and 6 extending thereacross and formed according to my invention, and will be described in greater detail below. The beam after passing through grids 5 and 6 to be velocity modulated is directed through a tubular conducting member 20 providing a field-free space in which the velocity modulated electrons are grouped. The grouped electrons are directed through the second resonator 4' provided with grids 5' and 5''. Insulating cup-shaped members 21 and 22 are sealed to resonators 4 and 4' and provide with the resonator an envelope which may be evacuated. The resonator 4 is made as shown in greater detail in Figure 2 and the resonator 4' employs the two types of grids shown in Figures 3 and 4.

Referring now to Figure 2 of the drawing, the hollow resonator 4 of toroidal form and shown in Figure 1 has a pair of large apertures at its center providing a gap through which electrons can pass to become velocity modulated, the apertures being provided with a pair of grids 5 and 6. It will be observed that the distance between the grids 5 and 6 is increased at their centers as indicated in the drawing by making the grids of partially spherical form, so that when a beam of electrons is directed therethrough the transit time of the axial electrons when passing through the oscillatory field at the gap is increased compared with the transit time of the marginal electrons so that the degree of velocity modulation imparted to the axial and marginal electrons is made more nearly the same. The variation of distance between the grids can be so proportioned over the area of the grids that the degree of velocity modulation is more nearly the same for all electrons no matter what part of the grids the electrons pass. It will be appreciated that, if desired, only one of the grids may be partially spherical the other grid being flat.

Figure 3 of the drawings illustrates the invention as applied to grids in the form of meshes. In this case, instead of the distance between the grids being varied as in Figure 1, the distance between the grids is left constant and the sizes of the meshes of each grid varied over the area of the grids as indicated. It will be seen from Figure 3 that the sizes of the meshes at the center of the grid 5' of resonator 4' are larger than the sizes of the meshes towards the periphery of the grid. It will be appreciated that the effect of making the meshes larger at the center of the grids is to permit the oscillatory field to spread more beyond the grids at their centers than at their peripheries. Thus, by suitably graduating the sizes of the meshes the transit time of the axial electrons can be increased as aforesaid.

Figure 4 of the drawings shows a resonator 4'' having a different kind of grid 5'' which is composed of a plurality of thin circular bars 7 arranged concentrically with one another, as shown, the bars being maintained in position relatively to one another by radial supports 8. In this case the spacing between adjacent bars decreases from the center of the grid to the periphery, as shown. In Figure 2 only one of the grids need have different size of mesh or bar spacings. This is true of any of the forms used in the resonator.

If desired, a combination of the grid structures shown in Figures 1 and 2 or Figures 1 and 3 can be employed.

The invention is not limited in its application to resonators having circular symmetry since it can be applied to resonators of other shapes and having apertures other than circular, and also to resonators in which annular gaps are employed.

In electron discharge devices of the velocity-modulation type the buncher and catcher resonator can be constructed with advantage in accordance with the invention although of course the invention is not limited in its use with electron discharge devices employing a pair of resonators.

While we have indicated the preferred embodiments of our invention of which we are now aware and have also indicated only one specific application for which our invention may be employed, it will be apparent that our invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of our invention as set forth in the appended claims.

What we claim as new is:

1. An electron discharge device having a cathode for providing a beam of electrons and an electrode toward which said electrons are directed, and a cavity resonator positioned between said cathode and said electrode, said cavity resonator having large apertures in opposite walls thereof and through which the path of the beam of electrons passes, grids positioned across said apertures, said grids being spaced further apart at the center of said grids than at their peripheries.

2. An electron discharge device having a cathode for providing a beam of electrons and an electrode toward which said electrons are directed, and a cavity resonator positioned between said cathode and said electrode, said cavity resonator having large apertures in opposite walls thereof and through which the path of the beam of electrons passes, grids positioned across said apertures, said grids having oppositely disposed concave surfaces whereby the centers of the grids are spaced further apart than the peripheries of the grids.

ALBERT FREDERICK PEARCE.
NORMAN CHARLES BARFORD.

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