

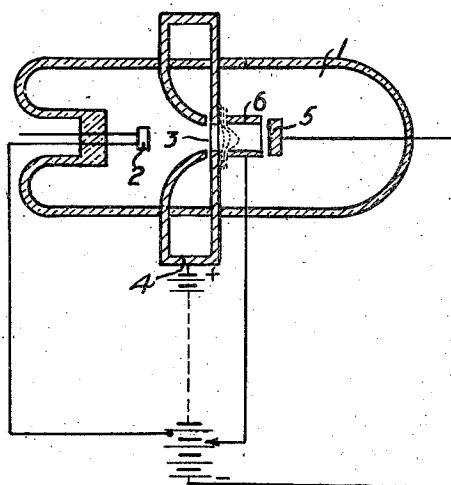
March 18, 1947.

S. HILL

2,417,551

ELECTRON DISCHARGE DEVICE AND ASSOCIATED CIRCUIT

Filed May 1, 1943



INVENTOR
Stanley Hill
by *H.S. Grover*
ATTORNEY

UNITED STATES PATENT OFFICE

2,417,551

ELECTRON DISCHARGE DEVICE AND
ASSOCIATED CIRCUITStanley Hill, Heston, England, assignor to Electric
& Musical Industries Limited, Hayes, Middlesex,
England, a company of Great BritainApplication May 1, 1943, Serial No. 485,290
In Great Britain January 17, 1941

3 Claims. (Cl. 315-5)

1

This invention relates to electron discharge devices of the velocity-modulation type employing hollow resonators and in which a stream of electrons after having been velocity-modulated by passing through the resonator gap is adapted to be reflected by the provision of a reflecting electrode back through the resonator to excite the resonator, the electrons travelling through a sufficient distance to enable bunching of the electrons to occur.

It is found, however, that the efficiency of a device of this type when operating as a generator of oscillations is rather low when operating with a low current and a high resonator potential and this is to some extent due to the unsuitable potential distribution of somewhat parabolic form in the space between the resonator and the reflecting electrode whereby only a small degree of bunching occurs. I have found that the efficiency of devices of the kind referred to can be substantially improved by arranging that the field gradient in the space between the resonator and the reflecting electrode has a positive or zero value over at least half the distance between the middle of the gap in the resonator and the zero equi-potential surface which is set up in operation between the resonator and the reflecting electrode. The field gradient has the positive and negative values referred to herein when said values are derived from a plot of the potential distribution taken from the resonator to the reflecting electrode.

According, therefore, to one feature of the invention I provide an electron discharge device and a circuit of the type referred to wherein the construction and arrangement of the electrodes are such that with suitable potentials applied to the electrodes the field gradient along the path of the electrons between the resonator and the reflecting electrode has a positive or zero value over at least half the distance between the middle of the gap in the resonator and the zero equi-potential surface which is set up in the space between the resonator and the reflecting electrode. Such a field gradient can be obtained in a variety of ways, such as by shaping the reflecting electrode and the adjacent surface of the resonator in a suitable manner. However, I have found that a more convenient way of effecting an improvement in the efficiency is to introduce a

2

further electrode between the resonator and the reflecting electrode.

The shape of the further electrode will depend on the form of the electron beam and in cases where the electron beam is of a substantially circular form in cross-section, the further electrode may comprise a cylinder or disc surrounding the beam. Other forms of reflecting electrodes can be employed depending on the shape of the electron beam as will hereinafter be referred to.

A potential distribution between the resonator and the reflecting electrode which passes from a positive value at the resonator linearly with distance through zero to a negative value at the reflecting electrode provides a constant potential gradient throughout the space and hence the field gradient is always zero. Such a field gradient affords a much better result than is the case if the field gradient is positive. A zero field gradient can be approximated in practice by providing a large number of further electrodes between the resonator and the reflecting electrode, the further electrodes being maintained at slightly different potentials passing from a positive value at the further electrode closest to the resonator to a negative value at the further electrode closest to the reflecting electrode, the potentials applied to the further electrodes being so chosen that the potential distribution is substantially linear. Such an arrangement is, however, cumbersome in practice and hence, for practical purposes, it is preferred to employ a minimum number of further electrodes.

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 drawing which illustrates one form of discharge device provided with a further electrode in accordance with the invention.

As shown in the drawing, the reference numeral 1 indicates the evacuated envelope of the device having at one end a cathode 2 which is arranged to project a beam of electrons through the gap 3 in a hollow resonator 4, the electron stream passing through the resonator being directed towards a reflecting electrode 5. The hollow resonator 4 is of toroidal form having the cross section shown and is arranged partly within and partly outside the evacuated envelope 1. In accordance with one feature of the invention a

3

further electrode 6 is provided arranged between the resonator 4 and the electrode 5. When operating the device shown in the drawing as a generator of self-maintained oscillations, a low current of about 10 to 5 milliamperes is employed and the resonator 4 is maintained at a high potential of about 1000 to 2000 volts positive with respect to the cathode 2 and the reflecting electrode 5 at a potential of 100-200 volts negative with respect to the cathode the further electrode 6 being maintained at a potential, preferably at a negative potential, intermediate the potentials applied to the resonator 4 and the reflecting electrode 5. The field gradient is changed by introduction of the electrode 6 which sets up between the resonator 4 and the reflecting electrode 5 equi-potential surfaces which are concave facing the resonator 4, as indicated by the dotted lines, these concave equi-potential surfaces extending over a distance along the path of the electrons which is longer than the distance over which concave surfaces would be set up in the absence of the further electrode 6, so that the field gradient has a positive value over at least half the distance along the path of the electrons between the middle of the gap 3 in the resonator and the zero equi-potential surface which is set up between the resonator and reflecting electrode. The zero equi-potential surface referred to herein is the equi-potential surface having the potential of the cathode of the device. In practice, the resonator may be maintained at earth potential and the cathode at about 1000 volts negative with respect to earth and the reflecting electrode at about 1100 or 1200 volts negative with respect to earth. In this case the zero equi-potential surface between the resonator and reflecting electrode will be the 1000 volts negative equi-potential with respect to earth. In some of the previously proposed resonators the wall of the resonator adjacent the reflecting electrode is symmetrical with the wall adjacent the cathode and such a construction of resonator is also found to impair the efficiency of operation owing to the re-entrant form of the rear wall. It will be observed that in the construction shown in the drawing the rear wall of the resonator is substantially flat in the vicinity of the reflecting electrode and this flattening of the rear wall of the resonator is also found to effect an improvement on the efficiency of operation.

The reflecting electrode 5 in the example shown is substantially flat although, in some cases, the reflecting electrode 5 may be of concave form with the concavity facing the resonator.

The disposition of the electrode 6 in relation to the resonator 4 and reflecting electrode 5 and the dimensions of the electrode 6 are not critical and in one form of the invention, given purely by way of example, in a case where the resonator 4 is tuned to operate at a wavelength of 9 centimetres, the electrode 6 may comprise a cylinder, about 6 millimetres in diameter and the length of the cylinder may be about 3 millimetres. The distance between the rear wall of the resonator and the reflecting electrode may be about 5 or 6 millimetres. The diameter of the apertures forming the gap in the resonator 4 may be about 3 or 4 millimetres in diameter.

The device shown is intended to be employed with an electron beam of a substantially circular form in cross section and in this case the further electrode 6 will also preferably be of circular form in cross section. Instead, however, of employing a cylindrical electrode one or more apertured

4

diaphragms may be employed, these apertured diaphragms also serving to provide the required field gradients and by employing more than one apertured diaphragm or more than one of the cylindrical electrodes, shorter in length than that mentioned above, and maintaining these electrodes at potentials which are progressively more negative towards the reflecting electrode 5, the distance along the path of the electrons over which the concave equi-potential surfaces are set up can be increased, and the field gradient can be caused to approach closer to the zero field gradient referred to above.

The features of the present invention can also be applied to electron discharge devices which employ ribbon-shaped beams. In this case the further electrode 6 will be shaped appropriately and may comprise a cylinder having an elongated cross-section or a diaphragm having an elongated opening or, alternatively, may comprise a pair of flat strips lying substantially parallel to the major axis of the ribbon-shaped beam as viewed in cross section. The pair of strips will be maintained at the same potential.

The features of the invention can also be applied to electron discharge devices where an electron stream flows radially through an annular gap in a resonator. In this case the further electrode may comprise a pair of rings lying one on each side of the beam.

What I claim is:

1. A high frequency apparatus including a source of electrons and an electrode toward which said electrons are to be directed, and a cavity resonator positioned between said source of electrons and said electrode, electrode means between said resonator and said electrode, means including a source of voltage and conductors connected between said source of voltage and said resonator, said electrode and said electrode means for maintaining said resonator at a high positive potential with respect to said cathode, said electrode at a negative potential with respect to said cathode, and said electrode means at a potential intermediate that of the resonator and said electrode.

2. A high frequency apparatus including a source of electrons and an electrode toward which said electrons are to be directed, and a cavity resonator positioned between said source of electrons and said electrode, electrode means between said resonator and said electrode, said electrode means comprising a tubular ring-like member closely surrounding the electron path and spaced closely adjacent said resonator and said electrode, means including a source of voltage and conductors connected between said source of voltage and said resonator, electrode and electrode means for maintaining said resonator at a high positive potential with respect to said cathode, and said electrode at a negative potential with respect to said cathode, and said electrode means at a potential intermediate that of the resonator and said electrode.

3. A high frequency apparatus including an electron discharge device having a source of electrons and an electrode toward which said electrons are to be directed, a cavity resonator positioned between said cathode and said electrode and through which electrons are directed during operation of said apparatus, and only a single tubular electrode means positioned between said resonator and said electrode and through which the path of the electrons extends between said resonator and said electrode and closely sur-

5

rounding said path, said resonator having a flat surface adjacent said tubular electrode means and transverse to the path of the electrons, and a voltage source having conductors connected between said voltage source, said resonator, electrode and electrode means for applying a positive potential to said resonator and a negative potential to said electrode with respect to said cathode, and a potential intermediate said two potentials to said tubular electrode means, whereby the field gradient along the path of the electrons between the resonator and the electrode has a value other than negative at least half the distance between the middle of the gap in the resonator and the zero equipotential surface

which is set up in the space between the resonator and the reflecting electrode.

6

STANLEY HILL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,325,865	Litton -----	Aug. 3, 1943
2,242,249	Varian et al. -----	May 20, 1941
2,329,778	Nergaard -----	Sept. 21, 1943
2,293,151	Linder -----	Aug. 18, 1942
2,190,511	Cage -----	Feb. 13, 1940