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DEVICE FOR DIVIDING A BEAM OF PARTICLES
EMERGING FROM A PARTICLE ACCELERATOR
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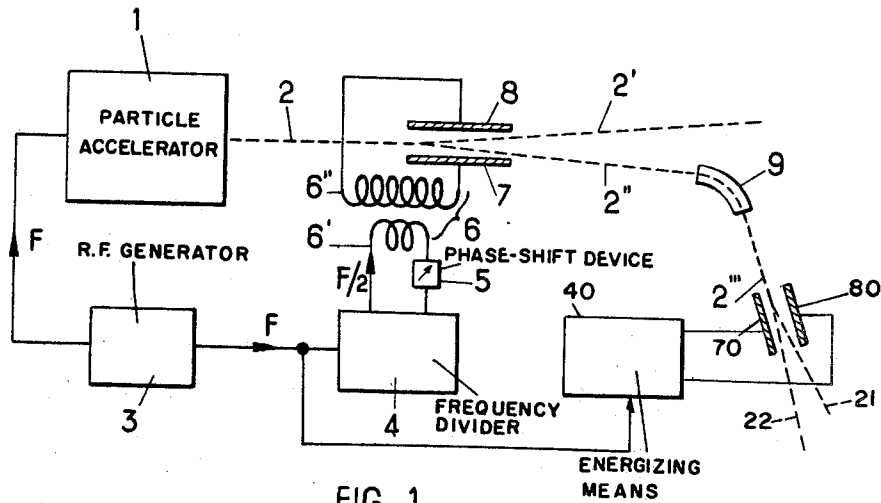


FIG. 1

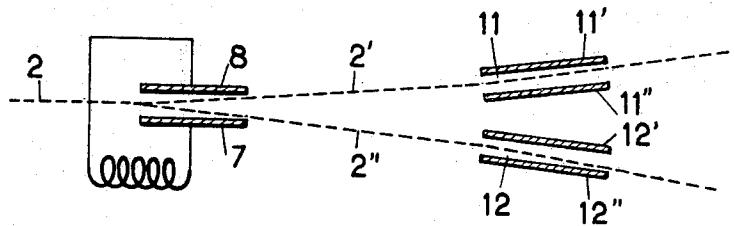


FIG. 2

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1

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**DEVICE FOR DIVIDING A BEAM OF PARTICLES
EMERGING FROM A PARTICLE ACCELERATOR**

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6 Claims

ABSTRACT OF THE DISCLOSURE

A device for dividing a beam of particles emerging from a particle accelerator in which at least one set of deflecting electrodes are placed along the path of the particle beam, and in which energization of the deflecting electrodes is realized by means of alternating voltage of half the frequency of the voltage used in connection with the accelerator. A phase-shift network may be inserted to adjust the deflecting voltage in relation to the beam. Additionally, another set of similar deflecting electrodes may be placed along the path of each subdivided beam so that any number of partial beams can be obtained from the original beam.

Background of invention

The present invention relates to particle accelerators and more particularly to the utilization of particle beams emerging from high frequency accelerators.

The particle output yielded by an accelerator is generally much higher than it is needed in most cases where a beam of accelerated particles is employed. It is therefore highly desirable to be able to divide a particle beam emerging from an accelerator into several beams of lower intensity, propagating in different directions, in order that several users, placed if necessary in different premises, may proceed simultaneously with their respective experiments.

To this effect it has been proposed to divide the beam at the output of an accelerator into pulses transmitted successively in different directions by means of pulse energized electrostatic or electromagnetic deflector devices, or alternatively to interrupt the beam by means of a rotating obturator which carries on a portion of its surface one of the targets, or in yet another arrangement to divide the beam physically by causing it to fall onto a thin blade ("septum") located on the axis of the beam so as to define two zones in which an electric field is established, whereby the divided beam diverges in two distinct directions.

These known systems have various disadvantages. Separation by pulses requires the use of high powers and even in very carefully constructed systems there exists a period of transition between the states of deflected and non-deflected beam, during which period the beam sweeping the intermediate space strikes the conduit (piping) walls and produces thereon secondary radiations which hinder the measurements. Moreover, irradiation by discrete pulses does not produce exactly the same effects as a continuous irradiation of a lower, instantaneous intensity. The same disadvantage is also inherent in the rotating system which likewise generates secondary perturbation radiations, beside the difficulties of constructing the rotating system in vacuo, introducing therein the targets and suitably cooling them. The system of separation by "a septum" likewise produces secondary radiations and its construction presents great practical difficulties. Since the septum must absorb as little as possible of

2

the incident beam, it should have a small cross section and yet be suitably cooled. In practice, rapid erosion takes place and the working life of this element is greatly reduced. Moreover, the septum must be removable in order to permit the use of the direct beam when required.

Summary of the invention

It is an object of the present invention to provide an improved dividing device in which the above disadvantages are eliminated or effectively reduced for use with accelerators operated by alternating voltages, that is, in cyclotrons, synchrotrons, synchrocyclotrons, linear accelerators using either travelling or standing waves, etc.

This invention makes use of the fact that the particle beam produced in accelerators operated by alternating voltages is formed by a sequence of particle groups or bunches at the rate of one group per cycle of the accelerating voltage, and provides electrostatic means for deflecting the successive particle groups alternately in two different directions so as to form in these directions two beams having each an intensity equal substantially to one-half of the initial beam intensity.

The present invention consists in a device for dividing a beam of accelerated particles emerging from an accelerator fed by an alternating accelerating voltage of frequency F , wherein there are provided two plane electrodes located one on either side of the beam to be divided, a source of alternating voltage of frequency $F/2$, connected between said two electrodes, and a phase shift device allowing the phase difference to be adjusted between F and $F/2$.

For a phase difference suitably adjusted, the alternating electric field of frequency $F/2$, set up between the two electrodes, has its highest values, alternately positive and negative, just during the time intervals in which the successive particle groups traverse the space defined between the electrodes, and these groups are deflected alternately toward each of the two electrodes thus forming two new beams having different directions.

In the accompanying drawings:

FIGURE 1 represents schematically one arrangement in accordance with the invention; and

FIGURE 2 is a modified arrangement in accordance with the invention.

In carrying the invention into effect according to one convenient mode by way of example, FIGURE 1 represents schematically an arrangement comprising a particle accelerator 1 which produces a beam indicated by the dotted line 2, a generator 3 of frequency F , supplying an accelerated voltage required for the operation of the accelerator 1, a frequency divider 4, producing an alternating voltage of frequency $F/2$ derived from the voltage of frequency F of the generator 3, a phase shift device 5 permitting the phase of voltage $F/2$ to be adjusted with respect to that of voltage F , a high frequency transformer 6 having a primary winding 6' and a secondary winding 6'', and two deflecting electrodes 7 and 8 located one on either side of the beam 2 and connected to the two terminals of the secondary winding 6'', respectively.

In operation, the space defined between the electrodes 7 and 8 is traversed (in a jerky fashion) by the beam 2 which is formed by particle groups or bunches succeeding each other at the frequency F . By suitably adjusting the phase of the voltage $F/2$ with the aid of the phase shifter 5 the highest values, alternately positive and negative, are given to the alternating electric field which prevails in the space defined between the electrodes 7 and 8 at the instants during the time periods when the accelerated particle groups are in this space. Under these conditions the particle groups or bunches are deflected alternately toward the two electrodes and thence propagate in two different directions 2' and 2''. Additionally, either of

3

the beams 2' and 2'', or both of them, can be deflected by means of magnetic deflectors. On FIGURE 1 such a deflector is indicated schematically at 9 where the direction of beam 2'' is deviated into 2'''.

Each of the divisional beams may, if desired, be divided again into two new beams of different directions, and so on. For example, in FIGURE 1, the divisional beam 2''' is divided into two new beams 21 and 22 by means of a similar dividing device comprising two deflecting electrodes 70 and 80 and an energizing means 40 similar to that which energizes electrodes 7 and 8.

In the modified arrangement, represented by FIGURE 2, the two beams 2' and 2'', emerging from the deflector 7, 8, traverse additional electrostatic deflectors 11 and 12, respectively. These additional deflectors comprise each a pair of plates (11' and 11'', 12' and 12'') between which there is established a direct current electric field, provided by a source of voltage not shown.

It will be noted that the arrangements of FIGURES 1 and 2 permit the use, as desired, of either the two divisional beams 2' and 2'', or only the initial beam 2. In the latter case, it suffices indeed to switch off the voltage $F/2$ so that the beam 2 passes between the electrodes 7 and 8 without being deflected.

While I have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to a person skilled in the art, and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A device for dividing a beam of accelerated particles emerging from an accelerator fed by an alternating accelerating voltage of frequency F and for supplying thereby two divisional beams, said device comprising two plane

4

electrodes located one on either side of the beam to be divided, a source of alternating voltage of frequency $F/2$, connected between said two electrodes, and a phase shift device allowing the phase difference to be adjusted between said voltages at a frequency respectively F and $F/2$.

2. A device as claimed in claim 1, further comprising additional deflector means for further deflecting at least one of the divisional beams.

3. A device as claimed in claim 1, further comprising additional deflector means for further deflecting both divisional beams.

4. A device as claimed in claim 1, further comprising means for further dividing at least one of the divisional beams.

5. A device as claimed in claim 2, further comprising means for further dividing at least one of the divisional beams.

6. In a particle accelerator comprising means for applying to said accelerator an alternating accelerating voltage, a device for dividing a beam, consisting of a succession of bunches, at a predetermined frequency, of accelerated particles, comprising two plane electrodes located one on either side of said beam and energizing means, including phase-adjusting means, connected with said electrodes for applying thereto an A.C. voltage having a frequency equal to half said predetermined frequency.

References Cited

UNITED STATES PATENTS

2,269,688 1/1942 Rath ----- 313—69

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