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Pollard et al.

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[54] **LINEAR PARTICLE ACCELERATOR WITH COAST THROUGH SHIELD**

[76] Inventors: **Jesse I. Pollard,** Box 167, Conyngham, Pa. 18219; **Jesse I. Pollard, II,** Box 7181, University, Miss. 38677

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[51] **Int. Cl.** **H01j 23/00,** H01j 29/00

[58] **Field of Search** 313/63, 313/83; 328/233, 256, 227; 315/5.41, 5.42

[56] **References Cited**

UNITED STATES PATENTS

3,218,562	11/1965	Serduke	328/233
3,478,241	11/1969	Bliamptis et al.	313/63
3,555,332	1/1971	Schroeder	313/63
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3,387,176	6/1968	Currie et al.	313/63 X
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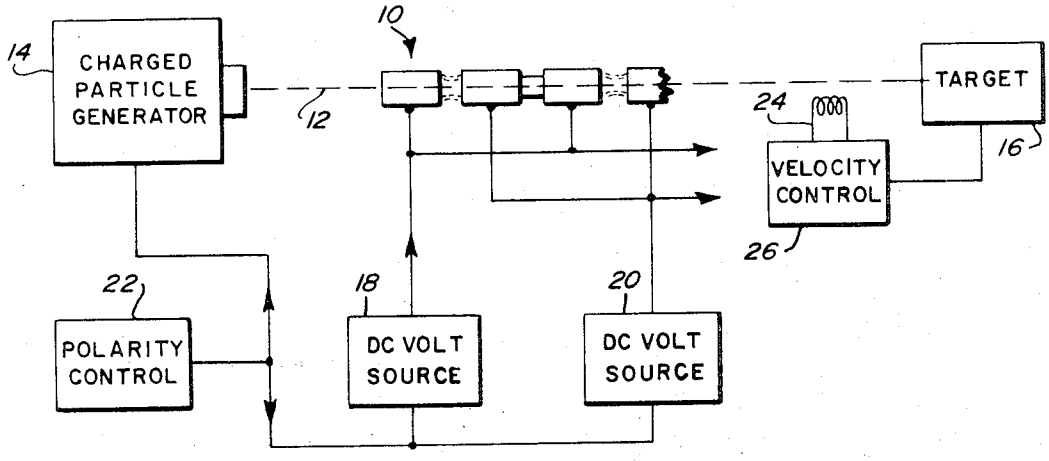
Primary Examiner—Stanley D. Miller, Jr.

Attorney—Clarence A. O'Brien and Harvey B. Jacobson

[57] **ABSTRACT**

Charged particles injected into an energy beam, are accelerated by electric fields established in gaps between tubular electrodes through which the particles pass. Alternate gaps between the electrodes are enclosed by tubular shields through which the particles coast between the accelerating fields. The electrodes are charged by d.c. sources of opposite polarity.

8 Claims, 4 Drawing Figures



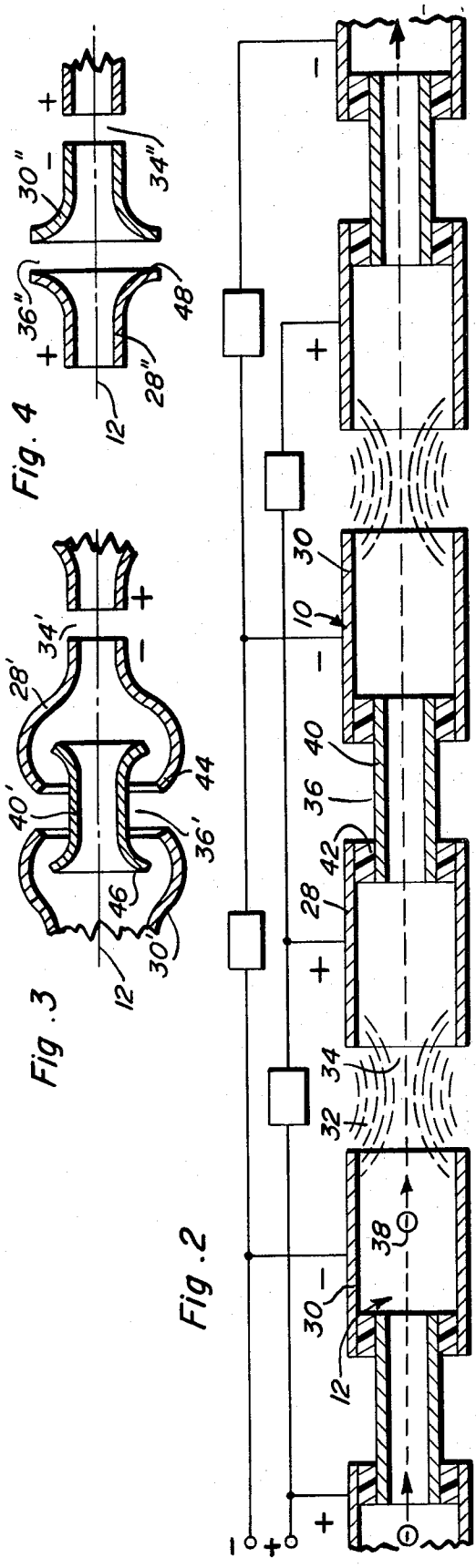


Fig. 4

Fig. 3

Fig. 2

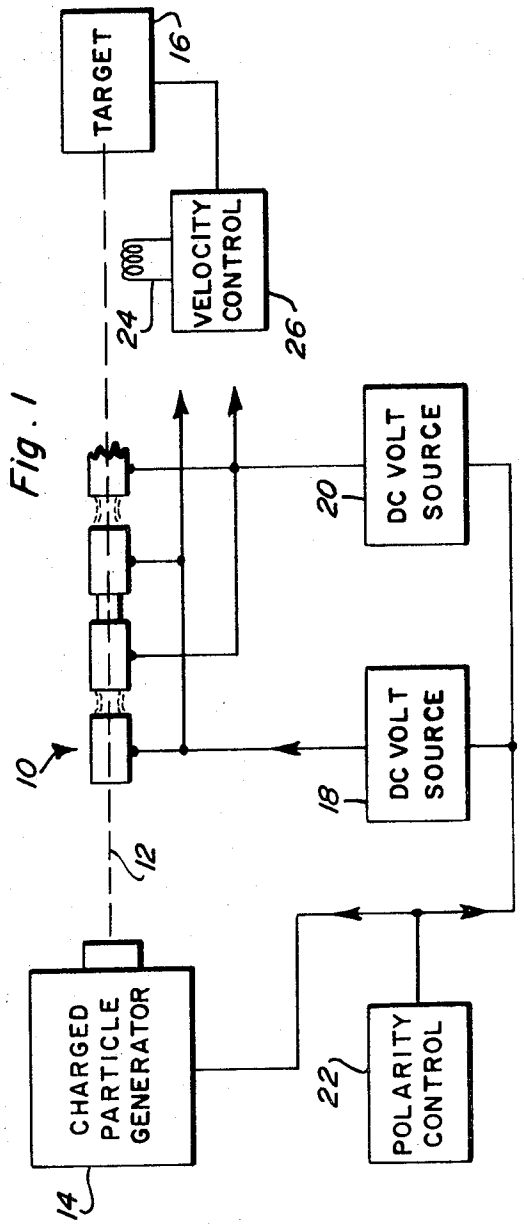


Fig. 1

Jesse I. Pollard
Jesse I. Pollard, II
INVENTORS.

BY Clarence A. O'Brien and Harvey B. Jacobson
Attorneys

LINEAR PARTICLE ACCELERATOR WITH COAST THROUGH SHIELD

This invention relates to the acceleration of charged particles by energy fields established between electrodes of opposite polarity to which direct current potentials are applied.

Charged particle accelerators employing spaced tubular electrodes between which accelerating energy fields are established, are well known as disclosed for example in U. S. Pat. Nos. 2,683,216 and 3,366,836. Most of such particle accelerators employ electrical accelerating fields of the oscillating type with various arrangements for focussing or directing the fields to produce the desired acceleration of particles such as electrons, protons, deuterons, ions, etc. In order to avoid the high power requirements and other problems inherent in the latter type of particle accelerator, it has been proposed to utilize d.c. potentials for the tubular electrodes. Such accelerators require special means to prevent deceleration of the particles between the unidirectional accelerating fields. Other disadvantages replacing those associated with accelerators utilizing oscillating accelerating fields are however introduced. For example, a particle accelerator utilizing direct current accelerating potentials exclusively, are disclosed in U.S. Pat. No. 3,218,562. The latter patent discloses shielding tubes between the accelerating electrodes that are connected to the source of potential and the accelerating fields are generated between the ends of the shielding tubes and the accelerating electrode rings. This field generating arrangement is relatively inefficient and the structure associated therewith is difficult to operationally align.

It is therefore an important object of the present invention to provide apparatus and a method for accelerating charged particles along linear paths, arcuate orbits, curvilinear trajectories or combinations of the foregoing paths by avoiding the use of oscillating potentials for the accelerating electrodes and without the field generating inefficiencies and structural instabilities associated with d.c. potential types of particle accelerators heretofore proposed.

In accordance with the present invention, a charged particle accelerator is provided with tubular or annular electrodes to which d.c. potentials are applied for establishing accelerating electric energy fields in the gaps between adjacent electrodes and preventing deceleration of the particles traveling from one accelerating field to another through the electrodes by permitting the particles to coast through tubular shields isolated from the electordes and the voltage supply means. The tubular shields are therefore positioned within alternate gaps between the electrodes. Accordingly, the charged particles are only affected by those fields in which they are accelerated in one direction thereby permitting the use of electrodes of fixed polarity.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a simplified electrical circuit diagram illustrating the system of the present invention.

FIG. 2 is a somewhat diagrammatic sectional view through a particle accelerator constructed in accordance with the present invention.

FIGS. 3 and 4 show modified forms of tubular electrode arrangements of the accelerator, in longitudinal section.

Referring now to the drawings in detail, FIG. 1 illustrates a linear accelerator generally denoted by reference numeral **10** through which an energy beam of charged particles **12** pass from a charged particle generator **14** to a target **16.** The charged particles acquire a relatively high velocity as a result of the energy withdrawn from energy fields established within the accelerator **10.** Energy is supplied to the accelerator from separate d.c. voltage sources **18** and **20** as diagrammatically shown having output potentials of opposite polarities. These may be any even number of Van de Graaff generators electrically independent of each other. The polarity of the voltage sources **18** and **20** will depend upon the polarity of the charged particles in the energy beam **12.** The polarity of the charged particles from the generator **14** and the corresponding polarities of the voltage sources **18** and **20** may therefore be reversed by any suitable polarity control component as shown in FIG. **1.**

Also, the energy beam **12** may be either continuous or pulsed. If a pulsed beam is utilized, energy in the form of a.c. current may be withdrawn from the beam. The particle velocity of the beam may be controlled at the high energy end by use of a transformer **24** and a velocity control component **26** to which the transformer is connected. Thus, full beam power can be maintained for prolonged periods of time without damage to the target **16** by draining power from the beam through the transformer **24.**

As more clearly seen in FIG. **2,** the particle accelerator comprises a plurality of spaced tubular electrodes or drift tubes **28** and **30** to which potentials of opposite polarity are applied from the aforementioned voltage sources **18** and **20.** Thus, electric energy fields **32** are established in alternate gaps **34** between adjacent ends of the tubular electrodes. In addition to the tubular electrodes, the accelerating energy fields **32** are separated by gaps **36** between the ends of adjacent tubular electrodes opposite the ends forming the accelerating gaps **34.** Thus, with electrodes **28** being positively charged and electrodes **30** being negatively charged, the energy fields **32** will accelerate negatively charged particles **38** in a right hand direction as viewed in FIG. **2** along the path of the energy beam with which the tubular electrodes are aligned. As hereinbefore indicated, the electrodes **28** and **30** are charged with d.c. potentials of fixed and opposite polarities. The polarities of the potentials applied to the electrodes **28** and **30** may of course be reversed in order to accelerate positively charged particles in the same direction.

In order to prevent deceleration of the particles passing through the gaps **36,** tubular shields **40** are positioned in alignment with the tubular electrodes and span the gaps **36** by projecting into or overlapping the tubular electrodes. These tubular shields **40** not only isolate the particles **38** from the electric energy fields in gaps **36** but also isolate them from the electrodes and the potentials applied thereto. Insulating spacers **42** between the metallic electrodes end shields as shown may be utilized to minimize leakage energy losses resulting from any current flow between electrodes of opposite

polarity through the shields **40.** Thus, charged particles accelerated by the energy fields **32,** may coast through the tubular shields **40** without any loss in kinetic energy.

As a result of the arrangement hereinbefore described, the need for costly apparatus in order to change the polarity of the electrodes is eliminated and the amount of power for sustaining operation substantially reduced.

Various configurations may be adopted for the tubular electrodes in order to reduce the decelerating energy fields in alternate shielded gaps. For example, the adjacent ends of the negative and positive electrodes **28'** and **30'** may be provided with bulbous formation **44** as shown in FIG. **3** to reduce fringing in gaps **36',** with the shields **40'** being flared at ends **46.** Alternatively, the adjacent ends **48** of electrodes **28''** and **30''** may be flared on either side of the decelerating gaps **36''** as shown in FIG. **4.** The accelerating gaps **34'** and **34''** in FIGS. **3** and **4** are formed between the smaller diameter ends of the electrodes.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed as new is as follows:

1. Apparatus for accelerating charged particles along a predetermined path comprising a plurality of electrodes spaced from each other by gaps along said path, voltage supply means connected to said electrodes for establishing energy fields unidirectionally accelerating said particles within alternate ones of said gaps, coast means positioned within the other of said gaps through which said particles pass between said accelerating fields, and means for isolating the coast means from the electrodes and the voltage supply means.

2. The combination of claim **1** wherein each of said electrodes is elongated in a direction along said path.

3. The combination of claim **1** wherein said coast means comprises tubular shields aligned with said electrodes along said path.

4. The combination of claim **3** wherein each of said electrodes is elongated in a direction along said path and has opposite ends, an associated one of said energy fields extending from one of said opposite ends and one of the tubular shields extending from the other of said ends.

5. The combination of claim **3** wherein said tubular shields project into the electrodes and are radially spaced therefrom by the isolating means.

6. The combination of claim **5** wherein the voltage supply means includes separate sources of constant d.c. voltage of opposite polarity respectively connected to alternate ones of the electrodes.

7. The combination of claim **1** wherein the voltage supply means includes separate sources of constant d.c. voltage of opposite polarity respectively connected to alternate ones of the electrodes.

8. The combination of claim **7** wherein said coast means comprises tubular shields aligned with said electrodes along said path.

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