Jan. 18, 1966 S. R. FARRELL 3,230,409

ROTATABLE CHARGED PARTICLE BEAM DEFLECTOR

Filed Jan. 3, 1962

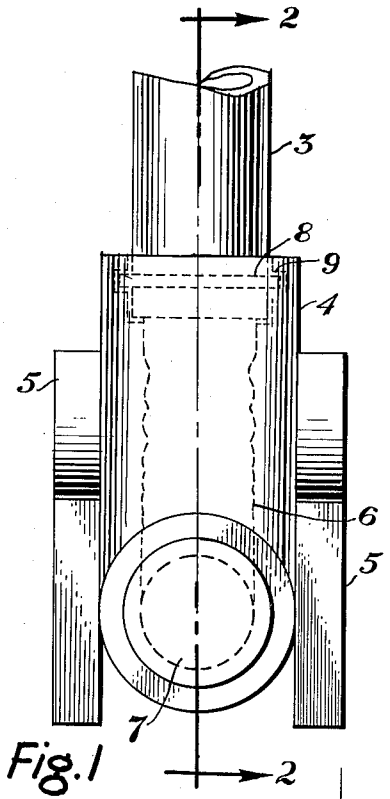


Fig. 1

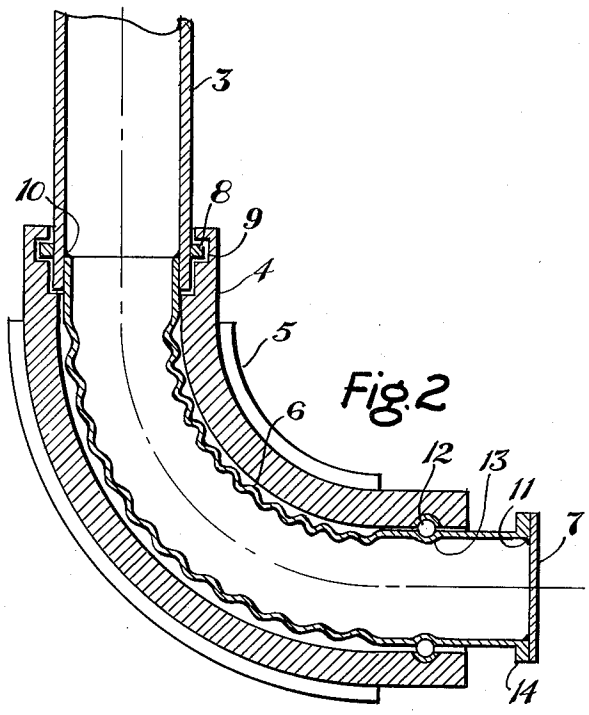


Fig. 2

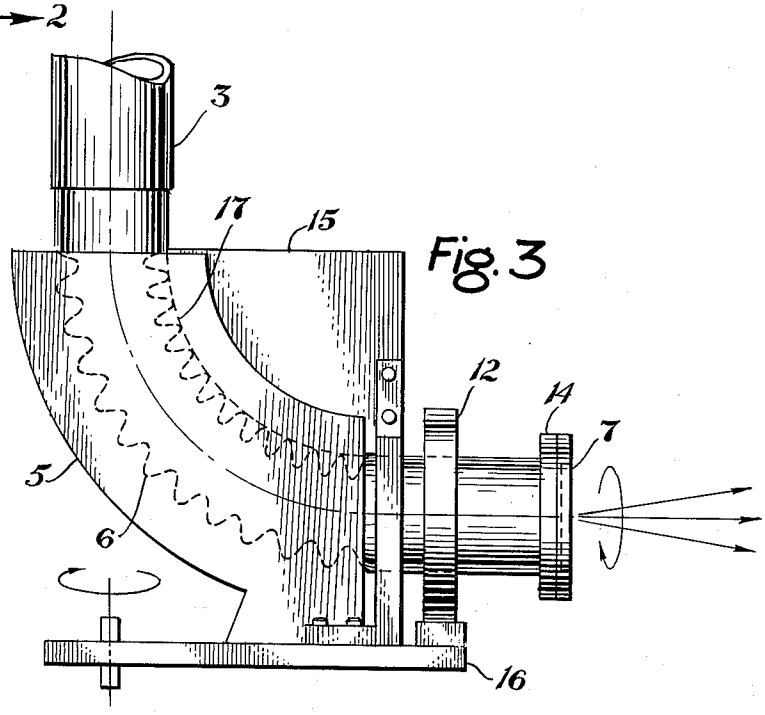


Fig. 3

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3,230,409 ROTATABLE CHARGED PARTICLE BEAM DEFLECTOR

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This invention relates to particle accelerators and apparatus for deflecting charged particle beams generated thereby. More particularly, it discloses a rotatable beam deflector that, through a novel combination and arrangement of bellows, bellows restraining means, and magnetic field producing means, provides 360° rotation of the deflected beam.

It is often desirable to utilize the beam generated by a particle accelerator in some direction other than that of its projected axis. This is especially true in the production of X-rays wherein space economies dictate that inherently long particle accelerating devices such as linear accelerators and Van de Graaff generators be disposed in a particular fixed position. Most commonly a 90° deflection of the projected beam is required. Further system flexibility is achieved by making the beam thus deflected rotatable about its original projected axis. Complete 360° rotation is most desirable, and in many instances required. A review of the current state of the art reveals that heretofore attempts to develop such a system have been predicated on the use of magnetic beam bending means in combination with a rotating vacuum joint. It is well known, however, that rotating vacuum joints are generally unsatisfactory and are replete with vexatious maintenance problems. Also, the rigid vacuum requirements of high power particle accelerators further dictate against the use therein of such a device.

Accordingly, it is a principal object of my invention to provide a new and improved rotatable charged particle beam deflector.

It is a further object of my invention to provide beam deflecting apparatus of the type described whereby 360° rotation of the deflected beam is achieved without resort to a rotating vacuum joint.

It is a still further object of my invention to provide a rotatable charged particle beam deflector wherein rotation of the deflected beam is achieved by means of a flexible metal bellows.

Another object of my invention is to provide, for use in conjunction with an electron linear accelerator, apparatus adapted to direct the beam generated thereby at right angles to the longitudinal axis thereof for the purpose of high density X-ray production where limited space is a controlling factor.

These, together with other objects and advantages will become apparent from the following detailed description of one presently preferred embodiment of my invention. While my invention is described with reference to specific structure, it is not intended that it be limited thereto, the full scope and nature thereof being defined in the appended claims.

In the accompanying drawings wherein like numerals refer to like parts throughout;

FIGURE 1 is a front view of one presently preferred embodiment of my invention;

FIGURE 2 is a sectional view of FIGURE 1 taken at 2—2; and

FIGURE 3 illustrates a second alternate embodiment of my invention.

Referring now to FIGURES 1 and 2, there is illustrated a rotatable charged particle deflector of the type comprehended by my invention. In operation, a charged particle

beam is generated in, and projected along the axis of, linear accelerator 3. The expression linear accelerator as used herein is intended to be construed in its broadest sense, including Van de Graaff generators, Cockcroft Walton accelerating tubes and the like. Flexible bellows 6, preferably of non-magnetic metal such as copper, is attached to the output end of linear accelerator 3. The junction therebetween is made by means of vacuum seal 10 thereby extending the vacuum system through bellows 6. The end of bellows 6 is provided with collar 14 to allow the attachment thereto of X-ray target 7. Vacuum seal 11 insures maintenance of the desired vacuum. Bellows restraining means 4, in the present illustrative embodiment, comprises a tubular right angle elbow member of non-magnetic material such as copper. The inner diameter of said bellows restraining means is roughly equal to the inner diameter of linear accelerator 3 and is in slideably contiguous relationship with bellows 6 therein disposed. The housing of linear accelerator 3 has disposed on the output end thereof annular collar 8, said collar 8 being operably engaged with annular groove 9 of bellows restraining means 4. Such an engaging relationship, then, allows bellows restraining means 4 to rotate freely around the longitudinal axis of linear accelerator 3. The end extremity of bellows restraining means 4 is provided with bearing means 12 disposed on the inner circumference thereof. Said bearing means 12 insures unrestricted precession of the output end of bellows 6 during deflector rotation. A uniform magnetic field is provided by magnets 5 thereby deflecting the charged particle beam passing therebetween the desired amount.

Referring now to the alternate embodiment of my invention illustrated in FIGURE 3, it is seen that for deflectors whose excess weight precludes the cantilever arrangement hereinbefore described, a mounting platform 16 may be provided upon which magnets 5, bearing 12, and bellows restraining means 15 may be mounted. The platform 16, in such an arrangement is maintained a fixed distance from the end of linear accelerator 3 and is made to rotate about the longitudinal axis thereof. In this embodiment it is only necessary to provide an arcuate sector 15 for the bellows restraining means. A concave arcuate surface 17 is sufficient to maintain bellows 6 in the correct position.

There has thus been disclosed novel apparatus whereby the several objects of my invention are accomplished. It is not intended that the invention thus disclosed be limited by the particular apparatus described since various modifications and applications within the spirit and scope thereof will occur to those skilled in the art. For instance, it is apparent that operation at various angles of deflection may be readily obtained and that various applications other than the production of X-ray beams may be utilized. Furthermore automatic rotating means and demountable, exchangeable units may be employed without departing from the scope of my invention. Therefore although specific apparatus has been described in setting forth my invention, it is not to be taken by way of limitation, the extent of my invention being defined in the appended claims.

I claim:

1. In a particle accelerator, a rotatable beam deflector comprising an evacuated flexible member having one end thereof in fixed relationship to the output end of said accelerator, said flexible member being positioned to admit the passage of the particle beam therethrough, means adapted to bend said flexible member and rotate the unsecured end thereof, and means adapted to bend said particle beam to conform to said flexible member.

2. A rotatable beam deflector as defined in claim 1 wherein said evacuated flexible member comprises an electrically conductive metal bellows.

3. A rotatable beam deflector as defined in claim 1 wherein said means adapted to bend said flexible member and rotate the unsecured end thereof comprises in combination, a platform means, said platform means being positioned a discrete distance from the output end of said accelerator normal to and rotatable about the longitudinal axis thereof, flexible member restraining means mounted thereon, said restraining means being contiguous to and arranged to constrain said flexible member in an arcuate configuration, and bearing means, said bearing means being mounted on said platform and adapted to rotate the unsecured end of said flexible member about the longitudinal axis of said accelerator without restricting the precession of said flexible member about its own axis.

4. A rotatable beam deflector as defined in claim 1 wherein said means adapted to bend said particle beam to conform to said flexible member comprises permanent magnet means disposed to provide a uniform magnet field in transverse relationship to said flexible member.

5. In a particle accelerator adapted to generate a high energy charged particle beam, a rotatable beam deflector comprising an evacuated flexible metal bellows having one end thereof fixedly attached to the output end of said accelerator, said bellows being aligned therewith to allow the passage of said charged particle beam therethrough, means adapted to bend said flexible member a bellows restraining member adapted to direct and rotate the output end of said bellows, said restraining member being in slideable relationship to said bellows to allow precession of the output end thereof, and means for providing a uniform magnetic field adapted to direct said charged particle beam through said bellows.

6. In a particle accelerator for generating a high energy electron beam along the longitudinal axis thereof, apparatus adapted to provide 90° deflection and 360° rotation of the electron beam projected thereby comprising a flexible electrically conductive metal bellows attached to the output end of said accelerator and arranged to provided an extension of the vacuum system thereof, a bellows restraining member, said restraining member being

rotatably affixed to the output end of said accelerator and operably engaged with said bellows to provide a 90° bend therein and to impart rotation thereof about the longitudinal axis of the linear accelerator, the output end of said bellows being free to precess on its own axis during said rotation, and means for providing a uniform magnetic field in transverse relationship with said bellows adapted to confine the electron beam therein.

7. In combination with a particle accelerator adapted to project a high energy electron beam along the longitudinal axis thereof, apparatus for bending said beam 90° and rotating said bent portion thereof around the longitudinal axis of said accelerator comprising a flexible electrically conductive metal bellows, one end of said bellows conforming with the output section of said linear accelerator and being affixed thereto through a vacuum tight seal, an X-ray target, said X-ray target providing a vacuum-tight closure to the end aperture of said bellows, bellows restraining means, said bellows restraining means comprising an electrically conductive tubular metal elbow member rotatably connected to the output end of said linear accelerator, said bellows being disposed therein and constrained thereby to form a 90° angle with the longitudinal axis of said linear accelerator, and permanent magnet means, said permanent magnet means being affixed to said bellows restraining means and adapted to provide a uniform magnetic field in transverse relationship to said bellows.

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