United States Patent [19]

Kuijpers

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[45] **Dec. 4, 1973**

[54] **ADJUSTING DEVICE FOR A PARTICLE BEAM**

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[22] Filed: **Aug. 25, 1971**

[21] Appl. No.: **174,887**

[30] **Foreign Application Priority Data**

Aug. 27, 1970 Netherlands 7012671

[52] **U.S. Cl.** ..... **315/31 R,** 250/49.5 D

[51] **Int. Cl.** **H01j 29/70**

[58] **Field of Search** ..... 250/49.5 D, 49.5 A; 315/31; 335/210

[56] **References Cited**

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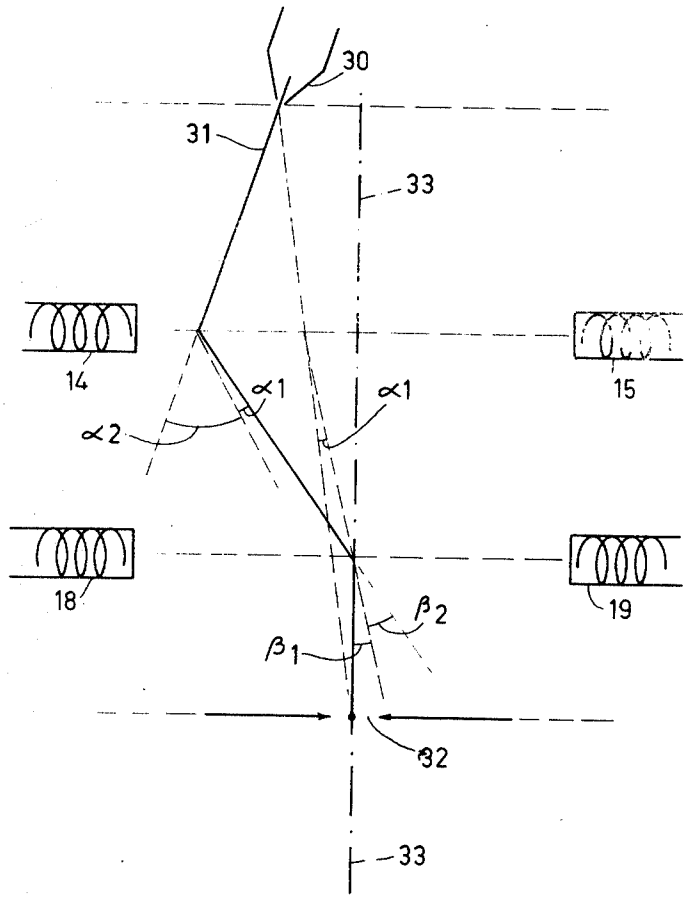
[57] **ABSTRACT**

An adjusting device for a charged particle beam in which the two desired beam movement facilities i.e., a deflection and a transverse displacement, are adjustable independently of each other. This is realized by providing an adjustable coupling between each two deflector elements of two deflection systems which follow one another in the beam direction.

9 Claims, 3 Drawing Figures



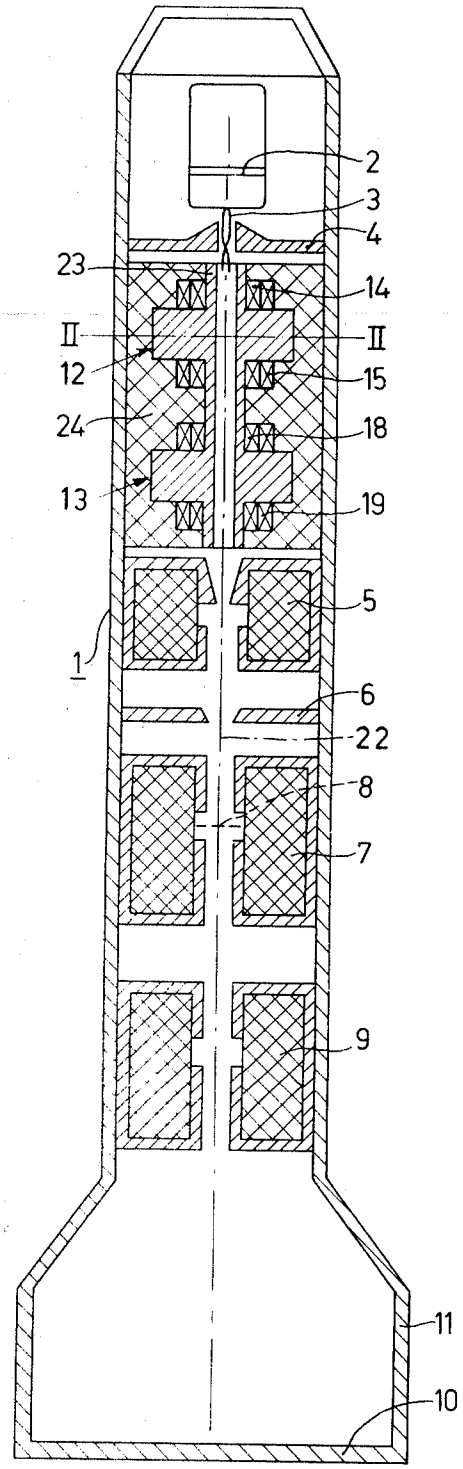


Fig.1

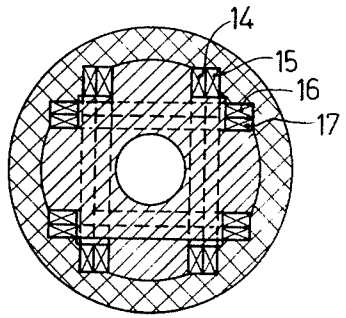


Fig.2

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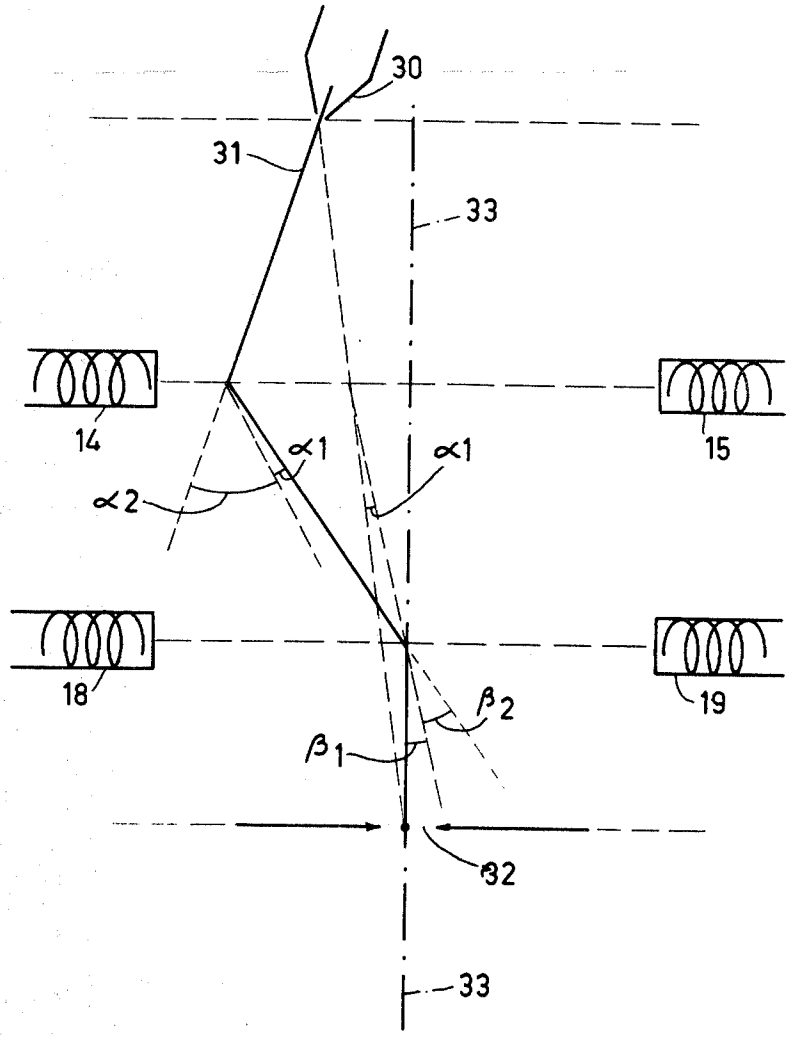

Fig. 3

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ADJUSTING DEVICE FOR A PARTICLE BEAM

An adjusting device of this type is used particularly in electron or ion-optical devices and serves to make the particle beam coincide with an optical axis of the device. For this purpose, an adjusting device of this type must be provided with two adjusting facilities by which a change in direction and a displacement of the beam at right angles to the direction of propagation can be imparted to the particle beam.

An adjusting device of this kind for use in an electron microscope is described in British Pat. No. 1,193,250. In the adjusting device described in this application an alternating field is applied to one adjusting facility, during adjustment of the other of the adjusting facility, so that the adjustment to be provided periodically is an optimum. Thus, each of the adjusting facilities can be adjusted while using the optimum passage of the other adjusting facility as a reference. A drawback of this method is the necessity to apply alternating fields to the deflection units, so that provisions against mutual influencing have to be taken. Furthermore, the intermittent behaviour of the reference moreover makes adjustment difficult.

The invention has for its object to provide an adjusting device in which either of the adjusting facilities can be adjusted independently of the other facility, while the motion of the beam may directly be observed, for example on an image screen. According to the invention, an adjusting device of the kind set forth is characterized in that the deflection systems are coupled so that the ratio of the deflection angles in both systems is inversely proportional to the distance of the plane of deflection of each of the deflection systems from an arbitrarily chosen third plane parallel with the deflection planes.

Owing to the coupling of the two deflecting systems it is possible, for example, to optimize a landing area of the particle beam on a screen for each adjusting facility and to perform each of the beam displacements consecutively. According to a preferred embodiment of the invention, the deflecting systems are formed by electromagnetic coils, which are coupled for one and the same energizing current strength by appropriate proportioning and winding.

The invention will now be described with reference to the accompanying drawing, in which

FIG. 1 is a diagrammatic cross-sectional view of an electron microscope provided with an adjusting device according to the invention,

FIG. 2 is a cross-sectional view taken on the line II—II in FIG. 1 of a deflection unit of the adjusting device, and

FIG. 3 shows diagrammatically the path of a particle beam with respect to an optical axis at the area of the adjusting device.

Referring now to FIG. 1, an electron microscope 1 contains, in the direction of propagation of an electron beam 3 emitted from an electron gun 2, in succession, for example, an accelerating anode 4, a condenser lens 5, a diaphragm 6, an objective lens 7, an object or specimen 8, a projector lens 9 and an image screen 10 which preferably forms part of an envelope 11 of the microscope 1. Mounted, for example, between the accelerating anode 4 and the diaphragm 6 are a first deflection system 12 and a second deflection system 13. Each of these two deflection systems can deflect the

electron beam 3 radially in any direction by means of a double system of deflector elements. In a preferred embodiment the deflector elements of the first deflection system consist of electromagnetic coils 14 and 15 and electromagnetic coils 16 and 17 (see FIG. 2) for two orthogonal directions of deflection, and the deflector elements of the second deflection system consist of electromagnetic coils 18 and 19 and electromagnetic coils 20 and 21 (not shown) which also serve for two orthogonal directions of deflection which preferably have the same orientations as the directions of deflection of the first deflection system. The two deflection systems are mounted one behind the other about an optical axis 22 of the electron microscope, as are the said electronic projector lenses and the diaphragm.

In the shown embodiment of the adjusting device, all the deflector coils are mounted in an aluminum block 23 which is mounted in a cylindrical casting 24, for example of araldite, which fits in the microscope column.

FIG. 2 is a cross-sectional view of the first deflection system, and shows, besides the araldite cylinder 24 and the aluminum block 23, the deflector coils 14, 15 and 16, 17, respectively, which are combined to form rectangular coil units. The proportioning and the number of turns, pair-wise of each of the deflecting system one coil unit, of the coils 14, 15 and 16, 17, respectively, and also of the coils 18, 19 and 20, 21, respectively, are such that the coupling desired according to the invention already substantially satisfies the imposed requirements at the same current intensity. Trimming resistors may be added for an exact adjustment. For the eight deflector coils it is sufficient to use four control units which can be operated by means of four control knobs.

The deflection elements can also be formed by electrostatic deflector plates or adjustable permanent magnets. By means of the two deflection systems, the electron beam is directed through the exposure diaphragm 6 in coincidence with the optical axis of the electron microscope. Viewed from the adjusting device, the exposure diaphragm may also be arranged in front of the condenser lens 5, or it may be formed by a diaphragm situated in the condenser lens.

FIG. 3 shows diagrammatically the operation of an adjusting device according to the invention, A particle beam 31 emitted from a source 30 is to pass through a diaphragm 32 along an optical axis 33. By way of example, in FIG. 3 a situation is chosen in which, for example, in a plane containing the deflection direction of the deflector elements 14, 15 and 18, 19, respectively, the particle source 30 is situated outside the optical axis, a principal direction of the particle beam 31 extending from the particle source at an arbitrary angle with the optical axis. The deflector elements 14 and 15 deflect the beam through an angle α_1 and the deflector elements 18 and 19 through an angle β_1. As a result of a coupling of the deflector elements according to the invention, the angles α_1 and β_1 will be inversely proportional to the distance between the relevant deflecting planes and a third plane, which in this case is a plane containing the diaphragm 6. Consequently, viewed from the position after the diaphragm, the beam is swung about the center of the diaphragm. In this way the center of the beam can be centrally directed on to the target screen. The image of the beam will not yet be symmetrical. In order to make the beam symmetrical, the beam is deflected through angles α_2 and β_2, respectively, in the same sequence by the deflection sys-

tems, the relationship of the angles being proportional again to the distances from the relevant deflection planes to a third plane, in this case is a plane containing the particle source **30.** This deflection results in a rotation of the beam about the particle source, so that the landing area of the screen can be made symmetrical. When both adjusting facilities have been optimally adjusted, the beam will pass through the center of the diaphragm **6,** where it will extend along the optical axis.

What is claimed is:

1. An adjusting device for a beam of charged particles having two deflection systems each deflecting the particles in two mutually perpendicular directions and having deflection planes which follow one another in the travelling direction of the particle beam, said deflection systems having a given coupling at which the ratio of the deflection angles in both systems is proportional to the distance of a given deflection plane of each of the deflection systems from an arbitrarily chosen third plane which is situated parallel to said deflection planes.

2. An adjusting device as claimed in claim **1,** wherein said the deflection systems include deflector units in both planes, so as to provide deflection in two mutually perpendicular directions at right angles to the direction of propagation of the beam.

3. An adjusting device as claimed in claim **1** wherein said deflection systems comprise electromagnetic coils, and means to adjust the energizing current for each of said coils to adjust the coupling between the deflection systems.

4. An adjusting device as claimed in claim **3,** wherein said the electromagnetic deflector coils are formed by rectangular coil units mounted on a support.

5. An adjusting device as claimed in claim **3** wherein the coils of both deflecting systems have a geometry and each have a number of turns whereby said coils have said given coupling when said coils are connected in series.

6. An electron-optical device comprising an electron source for generating an electron beam and, viewed in the direction of propagation of the beam, in succession an input diaphragm and an electron-optical system, and between the electron source and the input diaphragm an adjusting device including two deflection systems each deflecting the electrons beam in two mutually perpendicular directions and having deflection planes which follow one another in the travelling direction of the electron beam, said deflection systems having a given coupling at which the ratio of the deflection angles in both systems is proportional to the distance of a given deflection plane of each of the deflection systems from an arbitrarily chosen third plane which is situated parallel to said deflection planes.

7. An electron-optical device as claimed in claim **6,** wherein a plane at right angles to the direction of the beam at the area of the object point acts as the third plane for the beam.

8. An electron-optical device as claimed in claim **6,** wherein the plane at right angles to the direction of the beam at the area of the input diaphragm acts as the third transverse plane.

9. An electron-optical device as claimed in claim **6,** wherein the electron source and the plane containing the input diaphragm are combined in a mutually dependent manner to constitute the third plane.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,777,211 Dated December 4, 1973

Inventor(s) Wilhelmus Kuijpers

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, before line 1, insert --The invention relates to an adjusting device for a beam of charged particles having two deflection systems which each act in two mutually perpendicular directions and have deflection planes which follow one another in the direction of propagation of the particle beam.--

Signed and sealed this 29th day of October 1974.

(SEAL)
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PO-1050 (5/69)

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