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TILTABLE SPECIMEN HOLDER FOR ELECTRON MICROSCOPES
WITH ELECTRICAL DEFLECTING MEANS TO
WOBBLE THE ELECTRON BEAM IMAGE
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Fig. 1

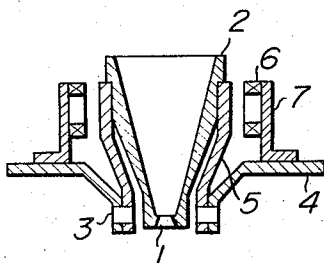
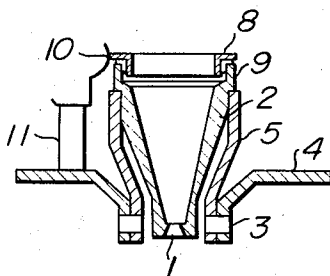


Fig. 2



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6 Claims. (Cl. 250—49.5)

This invention relates to electron microscopes, and more particularly to specimen tilting devices for use in electron microscopes.

In electron microscopes, specimen tilting devices are used when certain kinds of specimens, particularly crystalline specimens, such as metals, are examined or observed. For example, refer to the Journal of Electromicroscopy, vol. 12, No. 1, 2-9, 1963, pages 2 through 5. In using a specimen tilting device, tilting may be effected, while watching the microscopic image of the specimen on the fluorescent screen. For best results, tilting should occur about a particular axis on the specimen, for example, about the side of the outline of the image or about a line perpendicular to an internal structure line of the specimen. For example, see Figure 4 on page 4 of the above-identified Journal of Electromicroscopy article. Tilting may also be effected in the direction of a particular spot in the electron diffraction image. In the tilting device, its tilting axis is fixed in a particular direction with respect to the microscope housing, or it may be rotatable if a particular direction is selected as a reference starting point. On the other hand, the direction of the specimen with respect to the microscope housing is not constant, and therefore, in known tilting devices, the specimen must be rotated so that a particular axis on the specimen and the tilting axis are coincident with each other.

In electron microscopes employing convention magnetic-field lens, the microscopic image or the diffraction image will not represent the enlarged image of the specimen directly projected onto the fluorescent screen, but it usually represents an image which is rotated by a certain angle α . In such case, therefore, the image projected on the fluorescent screen will not indicate the actual positional relation of the specimen with respect to the microscope housing. In order to effect the tilting of the specimen with these known tilting devices, therefore, it is necessary to first measure the angle of rotation of the image and also the angle formed by the particular axis on the specimen with the tilting axis and then to operate the tilting devices according to the sum or balance of the said two angles. Such an operation of the device is complicated and lowers the efficiency of observation. In addition, to there being involved measurement errors of the two angles, accurate coincidence of the said both axes is difficult to obtain. Even if the angles are measured correctly, there is no designation of the tilting axis on the fluorescent screen under observation, and there cannot be obtained any confirmation of correct coincidence.

The primary object of the present invention is to provide a specimen tilting device for electron microscope having no such defaults or disadvantages as hereinabove pointed out.

Another object of the present invention is to provide a specimen tilting device of the kind specified in which said tilting operation can be accomplished without measuring said both angles, and wherein the direction of the tilting axis can be determined readily by viewing the fluorescent screen.

There are other objects and particularities of the pres-

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ent invention, which will be made obvious from the following detailed description of the invention, with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view of the essential parts of a specimen tilting device embodying the present invention, and employing an electromagnetic deflecting coil; and

FIG. 2 is a similar view showing another embodiment of the invention employing an electrostatic deflecting electrode.

When an electron beam alternately deflecting device, for example, a pair of coils or a ring electrode to which alternating or pulsed voltage or current is applied, is disposed in the direction of a tilting axis of the specimen tilting device or alternatively in the direction perpendicular thereto, the electron beam irradiating the specimen disposed in said tilting device is deflected alternately in the direction of the tilting axis or alternatively in the direction perpendicular thereto. As a consequence, wobbling of the electron beam takes place in the direction of the alternately deflecting field in the microscopic image (or the diffraction image) by virtue of the aberration of the electron lens. This appears to an observer of the fluorescent screen as a form of modulation. Even though the image might be rotated midway in any direction, the direction of the wobbling (or modulation) is always in the direction of the tilting axis, or alternatively, in the direction perpendicular to the tilting axis depending upon the design used.

In effecting the tilting of the specimen, it is only necessary to operate so as to bring a desired axis on the specimen into coincidence with the direction of the wobbling (in the case where the electron beam is deflected alternately in the direction of the tilting axis), or to bring the desired axis on the specimen perpendicular to the direction of the wobbling (in the case where the electron beam is alternately deflected in the direction perpendicular to the tilting axis). As has been discussed above, since the direction of wobbling (or modulation) indicates the direction of tilting, it is then known that the desired axis on the specimen is properly aligned with the tilting axis. Hence, by means of the present invention the desired objective can be obtained without conducting complicated measurements of angles as has been required with known tilting devices.

Further, instead of employing deflecting elements having deflecting effect laterally to the optical axis as above mentioned, deflecting elements having alternately deflecting effect in the direction of tilting, for example, ring-shaped electrodes or ring-shaped coils to which alternating or pulsed voltage or current is applied, may be disposed above the specimen and arranged to tilt in unison with the specimen. In the event that such ring-shaped electrodes are used, it will result in the electron beam being deflected alternately above and under the center axis of the electrode by the pin-hole lens principle as is described in, for example, the "Basic Electronics" (Kiso Denshi Kogaku) published on October 15, 1960, by the Institute of Electrical Engineers of Japan (Denki Gakkai), pages 21 through 22.

In the event that ring-shaped coils are used, a magnetic field will be produced in the direction of their center axis. Therefore, so long as the axis is coincident with the optical axis of the electron microscope, the electron beam will not be deflected. If, however, the center axis of the coil is inclined from the optical axis, this will cause the electron beam to be deflected. It will be apparent from the "three-fingers-of-the-left-hand rule" of Fleming that the direction of this deflection is perpendicular to the direction obtained in the case where the ring-shaped electrode is used.

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Accordingly, in the event the specimen is inclined, the electron beam will be deflected alternately in the direction of the tilting (meaning the case where the ring-shaped electrode is used) or in a direction perpendicular to the tilting axis, and there takes place wobbling as has been described earlier.

Referring now to FIG. 1, the specimen tilting device shown comprises holding means formed by a holder cylinder 2 for specimen 1, tilting shafts or axes 3, a stationary base 4, and tilting means comprised by tilting supports 5 for holder 2. The foregoing are parts found in conventional devices corresponding, for example, to parts H, D, E, and F in Figure 2, on page 3 of the Journal of Electromicroscopy article identified above. The manner of operation of these parts for effecting tilting is well known and is similar to those stated in the above-mentioned reference. In addition, coils 6 are provided for alternate deflection, and are mounted on coil supports 7. Coils 6 produce magnetic flux in the horizontal direction along the plane of paper, which alternately deflects the electron beam to the direction vertical to the paper plane. This direction is made coincident with the direction of tilting of the specimen 1, which is the direction perpendicular to the tilting axes 3.

The device shown in FIG. 1 may be modified as shown in FIG. 2. Electromagnetic deflecting coils in the former are replaced with an electrostatic deflecting electrode 8 supported by an insulator 9. A contact piece 10 is mounted on a contact support 11 and serves to apply an alternating or pulsed electric potential to electrode 8. This results in the establishment of a pulsed electric field gradient in the space between electrode 8 and member 2 that can cause deflection of the electron beam if it is not centered. As long as the specimen 1 is in the zero reference or horizontal position, the electrode 8 is symmetrical with respect to the optical axis, and there takes place no change in the image. However when the device is tilted, the center of electrode is displaced in the direction of tilting, and the electron beam is alternately deflected in the direction of tilting.

According to the invention as above explained, the orientation of tilting of the specimen or the direction of the axis of tilting on the fluorescent screen can be known direct when the tilting of specimen is being adjusted, and consequently, no complicated measurement of angles is required, and hence no error caused thereby. Further, since the direction of tilting can be observed on the fluorescent screen simultaneously with the image of specimen, there is no fear at all that tilting will take place in a wrong direction.

What is claimed is:

1. A specimen tilting device for electron microscopes, comprising holding means for holding the specimen to be examined, tilting means having a tilting axis acting on said holding means for tilting the specimen, electrical deflecting means physically aligned in a known and fixed manner relative to the tilting axis of said tilting means, and means for energizing said electrical deflecting means with an alternating electric signal for alternately deflect-

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ing the electron beam irradiating said specimen to thereby wobble the image of the electron beam in a definite direction with respect to the direction of tilting of said specimen.

2. A specimen tilting device for electron microscopes according to claim 1, wherein the electrical deflecting means acts in a direction perpendicular to the direction of tilt of the tilting means.

3. A specimen tilting device for electron microscopes according to claim 1, in which said electrical deflecting means includes a pair of coils.

4. A specimen tilting device for electron microscopes according to claim 1, in which said electrical deflecting means includes a ring-shaped electrode and wherein with the tilting means in the zero reference position the center of said electrode is made coincident with the optical axis of said electron microscope.

5. A specimen tilting device for electron microscopes comprising:

a supporting member physically supported on the column of an electron microscope,

specimen holding means physically supported by said supporting member in a tiltable manner, tilting means acting on said specimen holding means for tilting said specimen holding means in a desired direction about a tilting axis, electrical deflecting means physically secured to the supporting member and aligned in a known and fixed manner relative to the tilting axis of said tilting means, and means for energizing said electrical deflecting means with an alternating electric signal for alternately deflecting the electron beam irradiating the specimen to thereby wobble the image of the electron beam in a definite direction with respect to the direction of tilt.

6. A specimen tilting device for electron microscopes comprising:

a supporting member physically supported on the column of an electron microscope,

a tilting support having a tilting axis,

connecting means for movably connecting said tilting support with said supporting member,

specimen holding means supported by said tilting support for holding a specimen irradiated by the electron beam, electrical deflecting means physically supported by said holding means and tiltable therewith, and means for energizing said electrical deflecting means with continuously varying electrical energy for alternately deflecting said electron beam to thereby wobble the image of the electron beam in a definite direction with respect to the direction of the tilting axis.

References Cited by the Examiner

UNITED STATES PATENTS

2,802,110 8/1957 Kazato et al. ----- 250—49.5

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