APPARATUS FOR POSITIONING SPECIMENS IN ELECTRON MICROSCOPES OR ELECTRON DIFFRACTION CAMERAS

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ABSTRACT OF THE DISCLOSURE

Apparatus for translating specimen in three mutually perpendicular directions and tilting specimen about two mutually perpendicular axes. A double tilt specimen holding cartridge slides into a seat in a translational member which is moveable with respect to the fixed member having a seat in which the specimen holder can be seated such that the first and second pair of elements register with one another to render an operative connection between the second control means and the specimen holder member which operative connection is breakable by withdrawal of the specimen holder from the seat.

Preferably, the seat is in the form of a slideway and the body of the specimen holder has a slide portion to engage the slideway.

Preferably too, said first pair of elements are in the form of plungers slidably mounted on the body of the specimen holder and said second pair of elements are constituted by a pair of rocker arms pivotally mounted on the translational member.

In order that the invention may be more fully explained one presently preferred specimen manipulating apparatus which has been designed for installation in a commercial electron microscope will now be described in detail with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a front perspective view of part of the column of a microscope which is fitted with a specimen manipulating apparatus constructed in accordance with the invention;

FIGURE 2 is a section on the line 2—2 in FIGURE 1;

FIGURE 3 is a perspective view of the manipulating apparatus removed from the microscope column;

FIGURE 4 is a partly broken underneath view of the manipulating apparatus;

FIGURE 5 is a partly sectioned side elevation of part of the manipulating apparatus;

FIGURE 6 is a section on the line 6—6 in FIGURE 5;

FIGURE 7 is a section on the line 7—7 in FIGURE 2;

FIGURE 8 is a section taken generally on the line 8—8 in FIGURE 2;

FIGURE 9 is a section corresponding to FIGURE 8 but shows the apparatus in a different condition the specimen holding cartridge being removed;

FIGURE 10 is an enlargement of part of FIGURE 3;

FIGURE 11 is an underneath perspective view of part of the manipulating apparatus; and

FIGURE 12 illustrates the construction of the specimen holding cartridge.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The drawings show a housing 21 which is designed for installation as part of a column of a conventional commercial electron microscope at the microscope level, i.e., above the objective lens of the microscope. Housing 21 is fitted with a pipe 22 for connection to a vacuum pump and carries a conventional air lock chamber 23 which is fitted with a vacuum connection pipe 24. A manipulating apparatus in accordance with the invention is fitted within housing 21 so that it enables a specimen for examination to be translated in three mutually perpendicular directions and also to be tilted about two mutually perpendicular axes.

The manipulating apparatus comprises a base ring 26 made of an upper, internally rebated, ring portion 26A and a lower flat circular ring portion 26B which fit together to define an annular groove 25 in the inner periphery of ring 26. Ring 26 is fixed within the lower end of housing 21 and encircles a disc 27 provided with a peripheral flange 28 which projects into groove 25 of the ring and bears against a pair of annular pads 29 of "Teflon" or some other suitable antifriction material fitted to the upper and lower faces of the groove. There
is radial clearance between the outer edge of flange 28 and the root of groove 25 so that disc 27 is capable of limited movement horizontally in any direction with respect to the ring.

A pair of tags 30, 31 are fastened to the underside of disc 27 by fastening screws 32 so as to extend radially of the disc and perpendicularly of one another. The outer end of tag 30 is formed to define an outwardly facing funnel shaped shallow socket 33 which engages a ruby ball 34 fitted to the inner end of a short toggle pin 36. The outer end of toggle pin 36 is also fitted with a ruby ball 35 which is received within a deep pocket formed in the inner ends of a thrust rod 35. The outer end of tag 31 is formed to a knife edge 40 which engages directly the inner end of a second thrust rod 37. Thrust rods 35, 37 enter the microscope column below housing 21 from the interiors of a pair ofods 45 which project outwardly from the column. Within pods 45, the outer ends of the thrust rods engage a pair of bell cranks which are operable by vertical movement of a pair of screw adjustment rods 38 to move the thrust rods axially. The bell crank and adjustment rod mechanism and the pod mounting is of an entirely conventional type and has not been detailed in the drawings. The entirety of the thrust rods into the column may be sealed by vacuum seals generally known as "Wilson" seals, these allowing the thrust rods to slide through them while preventing the leakage of air into the column. These seals may be mounted in the inner ends of pods 45.

Disc 27 is biased by a helical tension spring 39 in a radial direction which approximately bisects the angle between tags 31. Spring 39 is connected between a pin 41 on disc 27 and a pin 42 on ring 26. By operation of adjustment rods 33, the thrust rods are moved to impart controlled movement to disc 27 in two mutually perpendicular directions against the action of biasing spring 39, the toggle pin and knife edge arrangement allowing independence of the two controls and the ruby balls reducing friction to a minimum.

Disc 27 supports a post 43 on which a rigid structure denoted generally as 44 is slidable mounted. Post 43 is of "quadrant" cross-section and has a pair of vertical slide grooves 46, 47. Structure 44 comprises a slide carriage 48 which is shaped to engage the two plain faces of the post and is fitted with tongues which engage grooves 46, 47 so that it is a good sliding fit on the post. The surfaces of carriage 48 which slide on the post are all Teflon coated to reduce friction.

A vertical screw 50 is rotatably mounted in a generally channel shaped bracket 49 which is fixed to housing 21. The lower end of screw 50 is fitted with a bevel gear 51 which meshes with a further bevel gear 52 mounted on the inner end of a shaft 53 which extends into housing 21 through a "Wilson" seal 54. Screw 50 can be rotated by rotation of shaft 53 from outside housing 21 and, to this end, the outer end of shaft 53 is fitted with a bevel gear 56 which meshes with a bevel gear 57 at the upper end of a vertical control rod so that rotation of the control rod drives screw 50.

Screw 58 carries a nut 59 which is provided with a slot to engage a vertically extending flange 60 on bracket 49 so that rotation of screw 50 causes the nut to travel vertically along it. Nut 58 carries a horizontal lug 61 the outer end of which is fitted with a ruby ball 62 which is a sliding fit within a recess 63 in carriage 48. Thus, as nut 58 is driven vertically along screw 50 on post 43, Ruby ball 62 fits within recess 63 with a small clearance so that it can slide within the recess with negligible friction during translational movements of disc 27.

It will be appreciated from the above description, that structure 44 can be moved vertically up and down partially by 43 by rotation of shaft 53 and can be translated horizontally in two mutually perpendicular directions by moving disc 27. Structure 44 further comprises a plate 66 which is mounted on carriage 48 by means of a mounting block 67 (formed integrally with it) and mounting screws 68. Plate 66 is provided with a generally U-shaped recess 69 to receive a double-tilt specimen holding cartridge denoted generally as 71. This cartridge is constructed in accordance with the invention described in our copending United States Patents No. 2,638,304, filed May 15, 1957, and, except for some minor modifications, it is substantially identical to the specific mechanism which is illustrated and fully described in that prior application.

In the present apparatus, the double-tilt cartridge is installed in an inverted position compared with the holder as described in the previous embodiment, the body plate 72 from which a hollow conical stem 73 extends. A small specimen holding ring 74 is pivotally mounted by means of a pair of ruby balls between the ends of a pair of arms 76 which extend along diametrically opposite sides of stem 73, the other ends of the arms being pivotally connected to opposite ends of a semi-circular rocker arm or yoke 77 pivotally mounted on body plate 72 by a screw 75 and disposed within an arcuate slot 80 therein. A third ruby ball is attached to the outer periphery of specimen holding ring 74 midway between the previously mentioned pair of balls and fits within a socket formed in the end of a third arm 78 of the extended conical stem 73. Near to the outer end of the conical stem, arms 76 and 78 are given lateral support by a "Delfin" collar 79 which holds them against the stem while allowing them to slide along it. Thus rocking movement of yoke 77 causes arms 76 to be moved equally in opposite directions to pivot the specimen holding ring 74 about an axis which intersects the first pivot axis perpendicularly at the centre of the specimen mounting ring. Ring 74 is housed within a small cap 81 fitted to the end of stem 73.

Cartridge body plate 72 is fixed to a slide 82 which carries a pair of plungers 84, 83. These plungers are pivotally connected to one end of yoke 77 and arm 78 respectively so that their movement will cause tilting of ring 74. A pair of helical compression springs 86, 87 bias plungers 83, 84 upwardly toward fully extended positions, ring 74 then having maximum tilt about both axes. Slide 82 is shaped to slide into a "dove-tail" slide-way 88 formed at the edges of recess 69. Slide-way 88 is convergent and slide 82 is shaped so that it will accurately locate in a position in which plungers 83, 84 register with the ends of a pair of tappet or rocker arms 89, 90 which are pivoting mounted between a pair of channel-shaped brackets 92, 93 fastened to one side of the plate 66. The other ends of tappet arms 89, 90 engage the upper ends of a pair of screw threaded rods 94, 95 which are rotatably mounted in brackets 93. Threaded rods 94, 95 are fitted with internally threaded bevel gears 96, 97 which mesh with further bevel gears 98, 99 carried at the end of a pair of universally jointed and telescopic shafts 101, 102 which extend out through the wall of housing 21 via "Wilson" seals 103, 104 where they are coupled to a pair of vertical control shafts 106, 107 via bevel gear couplings 108, 109. Thus, by rotating control shafts 106, 107 outside the microscope column, rods 94, 95 may be driven up and down to pivot tappet arms 89, 90. The tappet arms are biased into engagement with the upper ends of rods 94, 95 by a biasing spring 111 which is clamped to plate 66 and acts upwardly on the forwardly, it moves structure of tilt arms.

An angle flange 112 stands up from the upper face of slide 82 to define an open-sided socket which receives the inner end of a cartridge extractor rod 113. Rod 113 extends through a "Wilson" seal 114 in the end wall of air lock chamber 23 and is provided at its inner end with a lug 116. In order to remove the cartridge from the apparatus, tappet arms 89, 90 are lifted out of engagement with plungers 83, 84 by suitably rotating shafts 106, 107 and structure 44 is moved vertically on post 43 so
that slide 82 is at the level of extractor rod 113. The extractor rod is then pushed through the open sided slide 82 whereby specimen attaching arms are on slide 82, and is then turned through 90° so that lug 116 engages the end of flange 112 as is most clearly shown in FIGURE 9. The whole cartridge can then be withdrawn by extractor rod 113 into air lock chamber 23 from whence it may be completely removed from the instrument. The cartridge may be reinserted into the apparatus by a reverse procedure.

The components connecting slide 82 and body plate 72 are constructed of heat insulating material so that slide 82 is heat insulated from the remainder of specimen holding cartridge 71. A heat conducting plate 121 is mounted on a plate 122 of heat insulating material projecting downwardly from plate 66. Heat conducting plate 121 has leads of copper wire 120 attached to it and is accurately notched to suit the curved end of body plate 72 of the specimen holding cartridge. When the specimen holding cartridge is inserted into the apparatus, the accurate notch of plate 121 engages the end of body plate 72. Plate 121 is mounted on the insulating post 122 so that it can move slightly to align itself and ensure firm contact over the full length of the notch. By placing the outer ends of copper wire leads 120 in heat conducting relationship with a liquid nitrogen bath, the body plate 72 and stem 73 of the specimen holding cartridge can be cooled substantially to liquid nitrogen temperature to serve as a very effective decontamination shield.

It will be appreciated that when the cartridge is seated in slideway 88, the registration of tapped arms 89, 90 with plungers 83, 84 renders an operative connection between control shafts 106, 107 and the tilt controls of the cartridge whereby specimen holding ring 74 can be tilted about its two pivot axes by appropriate rotations of shafts 106, 107. However, this operative connection can readily be broken and the cartridge removed from the slideway by means which will now be described.

When the cartridge is fitted into the apparatus, it is moved downwardly by movement of structure 44 on post 43 so that the lower end of stem 73 extends downwardly through an aperture 122 until the specimen at the lower end of the stem is in the required level for examination. Aperture 122 is lined by a bushing 123 which is machined so as to receive the "Delrin" collar 79 on stem 73 with a close sliding fit. This provides very firm lateral support for the stem 73 and it has been found in operation of the apparatus that the specimen holding ring is held accurately to position and does not tend to "drift."

The vertical movement provided by the above described apparatus and the particular design of the tilt cartridge enables the specimen to be inserted downwardly into the objective lens of the microscope where it may be examined by a high resolution convergent beam technique. This has hitherto not been possible in electron microscopes but requires specially designed electron diffraction cameras. Moreover because of the range of vertical movements which can be achieved, the specimen can be moved upwardly out of the pole-piece to a position which is suitable for the examination of magnetic domains. The examination of magnetic domains has hitherto required special attachments which could only be fitted to the microscope by which specimen holding ring 74 was fitted. The fitted instrument was unsuitable for examination of the specimen at other positions. Thus, the above described apparatus enables many types of examinations to be carried out without altering the microscope set up and, what is more, the specimen holding cartridge can be rapidly removed and reinserted into the microscope with minimal loss of time. However, it is to be understood that this particular apparatus has been illustrated and described by way of example only and that the invention is in no way limited thereto but includes all modifications and adaptations which fall within the scope of the appended claims.

I claim:

1. Apparatus for manipulating specimens within an electron microscope or electron diffraction camera comprising a fixed structure; a translational member mounted for substantially translational movement with respect to the fixed structure in three mutually perpendicular directions; first control means operable controllably to move the translational member in each of said directions; a specimen holder comprising a stem, a tiltable member to support a specimen and mounted on the body for tilting movement about two mutually perpendicular axes with respect to the body, and a first pair of elements movably mounted on the body and operably connected to the tiltable member so that their movement tilts that member about said axes; a comp pair of elements each movably mounted on said translational member, and second control means operable to move said second pair of elements with respect to the translational member; the translational member having a seat in which the specimen holder can be seated such that the first and second pair of elements register with one another to render an operative connection between the second control means and the tiltable member which operative connection is breakable by withdrawal of the specimen holder from the seat.

2. Apparatus as claimed in claim 1, in which said seat is in the form of a slideway and the body of the specimen holder has a slide portion for insertion and withdrawal from the slideway.

3. Apparatus as claimed in claim 1, in which said specimen holder comprises a further pair of substantially parallel arms, and a lever pivotally mounted on the body of the specimen holder and pivotally connecting said arms so that it is pivotable to move the arms with respect to the body only in their longitudinal directions and said tiltable member is pivotally mounted between said arms by two pivot connections, one to each arm, which define a tilt axis extending through them and constituting one of said mutually perpendicular axes, one of said first pair of elements being connected to the lever so as to be movable to pivot the lever and thereby tilt the tiltable member about a second tilt axis which is fixed relative to the body of the specimen holder and constitutes the other of said mutually perpendicular axes, and the other of the first pair of elements being connected to the tiltable member so as to be movable to tilt it about said one tilt axis.

4. Apparatus as claimed in claim 3, in which the body of the specimen holder further comprises a hollow stem portion located between said pair of arms and extending longitudinally thereof.

5. Apparatus as claimed in claim 4, in which the specimen holder further comprises a collar which encompasses both said arms and said stem portion thereby to provide lateral support for said arms.

6. Apparatus as claimed in claim 1, in which said first pair of elements is constituted by a pair of plungers slidably on the body of the specimen holder and said second pair of elements is constituted by a pair of rocker arms pivotally mounted on the translational member, said second control means being operable to pivot the rocker arms on the translational member.

7. Apparatus as claimed in claim 6, in which the specimen holder is further provided with biasing means which biases the plungers toward predetermined positions, the second control means is operable when the specimen holder is seated on the translational member to move the rocker arms out of engagement with the plungers to leave them in their predetermined positions and is also operable to engage the plungers and move them from their predetermined positions against the action of the biasing means.

8. Apparatus as claimed in claim 1, and comprising a carrier mounted on the fixed structure for movements in two mutually perpendicular directions, the translational member being mounted on the carrier for movement there-
on perpendicular to the plane of the carrier movements and said first control means being such as to move the carrier with respect to the fixed structure and to move the translational member with respect to the carrier.

9. Apparatus as claimed in claim 8, in which the carrier comprises a plate and the translational member is slidable on a post fixed to the plate.

10. Apparatus as claimed in claim 9, wherein said specimen holder further comprises a pair of substantially parallel arms, a lever pivotally mounted on the body of the specimen holder and pivotally connecting said arms so that it is pivotable to move the arms with respect to the body equally and oppositely in their longitudinal directions, a hollow stem projecting from the body between said pair of arms and longitudinally of the arms, and a collar which encompasses both of said arms and said stem portion thereby to provide lateral support for said arms; wherein said tiltable member is pivotally mounted between said arms by two pivot connections, one to each arm, which define a tilt axis extending through them and constituting one of said mutually perpendicular axes; wherein one of said first pair of elements is connected to the lever so as to be movable to pivot the lever and thereby tilt the tiltable member about a second tilt axis which is fixed relative to the body of the specimen holder and constitutes the other of said mutually perpendicular axes, and the other of said first pair of elements is connected to the tiltable member so as to be movable to tilt it about said one tilt axis; and wherein said plate is provided with an aperture with which the collar of the specimen holder can be engaged by movement of the translational member along the post.

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