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ELECTRON OPTICAL INSTRUMENT WITH ADJUSTABLE SPECIMEN SUPPORT

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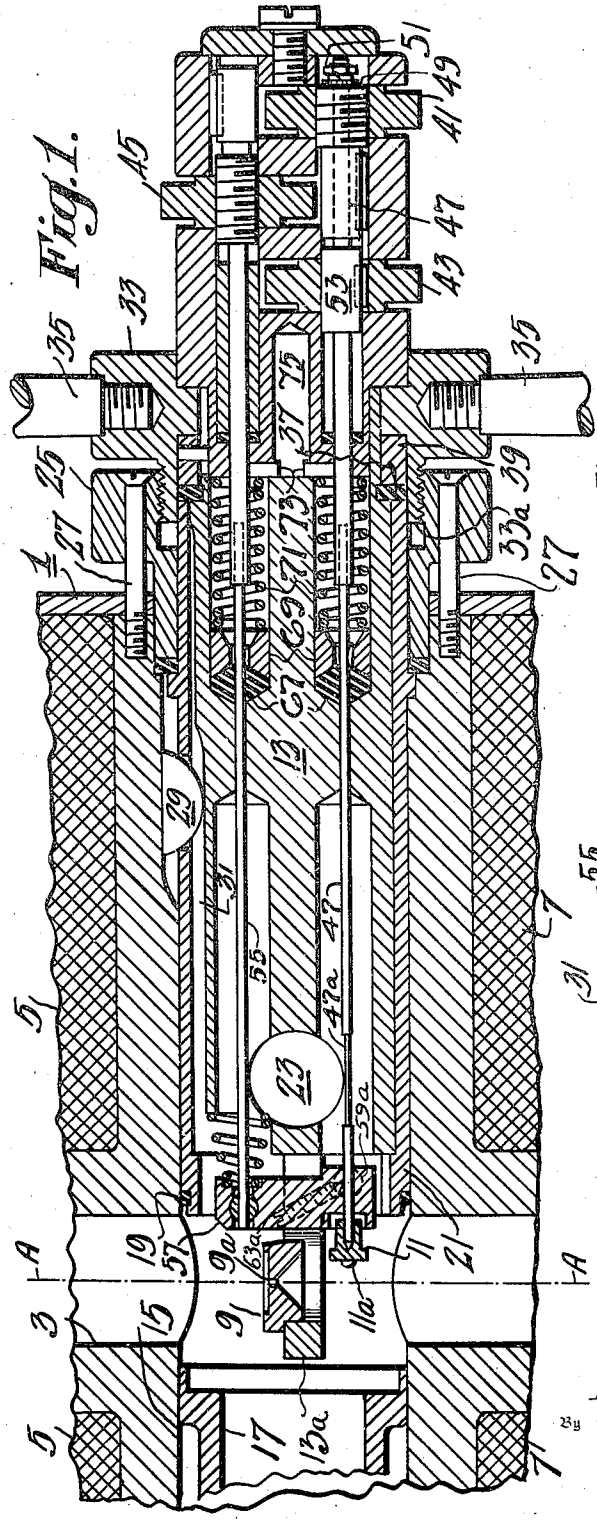


Fig. 1.

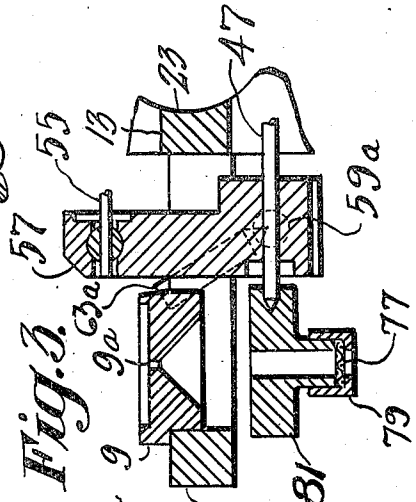


Fig. 3.

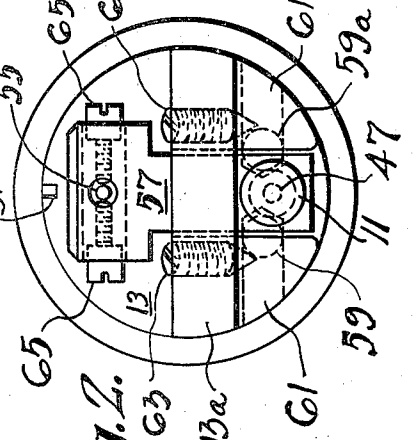


Fig. 2.

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ELECTRON OPTICAL INSTRUMENT WITH ADJUSTABLE SPECIMEN SUPPORT

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7 Claims. (Cl. 250—49.5)

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This invention relates to improvements in electron optical instruments of the type wherein the electrons are directed in the form of an undeviating beam upon either an opaque or a transparent specimen to produce a diffraction pattern or an electron image thereof, and has special reference to the provision of an improved specimen-holder for such instruments.

In operating an electron diffraction camera, or a transmission type electron microscope, it is often desirable to explore the specimen with the electron beam in order that the more interesting portions of the specimen may be viewed. Since in electron optical instruments of the general character described the electron beam passes in an undeviating path from its source to the target, the desired exploration can only be achieved by orienting the specimen-holder with respect to the beam. The present invention is predicated upon an appreciation of the fact that the ideal specimen-holder would be one capable of being moved in all directions with respect to the electron beam, without breaking the vacuum within the instrument. While certain specimen-holders of the prior art are capable of numerous adjustments certain of the adjustments could heretofore be made only when the vacuum is broken. (As to this, see U. S. Patent 2,275,234.)

Accordingly, the principal object of the present invention is to provide an improved specimen-holder for electron optical instruments of the general character described and one including a specimen mount capable of being oriented in all directions without breaking the vacuum in any part of the instrument in which it is used.

Another and important object of the invention is to achieve the foregoing advantages in a readily removable and compact specimen-holder, and one further characterized by its ease of assembly and by the simplicity and accuracy of its adjustments.

Still another object of the present invention is to provide an adjustable specimen-holder having interchangeable specimen mounts for use with various types of specimens and in different types of electron optical instruments.

Certain preferred details of construction together with other objects and advantages will be apparent and the invention itself will be best understood by a reference to the following specification and to the accompanying drawing, wherein:

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Figure 1 is a sectional elevation of an adjustable specimen-holder constructed in accordance with the present invention and shown mounted for use in an electron optical instrument,

Figure 2 is an end view, with the beam forming diaphragm removed, looking into the leading end of the specimen-holder of Fig. 1, and

Figure 3 is a sectional view of an alternative form of fixture for the specimen-holder of Fig. 1.

In Fig. 1, 1 designates generally an electron optical instrument containing a centrally located vertical conduit 3 having an electron axis A—A which is surrounded by magnetic coils 5 and 7 for directing the electrons downwardly from a source (not shown) along the said axis to a viewing chamber (not shown). The relative arrangement of the coils 5 and 7 forms no part of the present invention though it may here be mentioned that when the instrument here illustrated is to be used as a transmission type electron microscope only the coil 5 is energized (in which case it may comprise the projection lens of the microscope). On the other hand when, as in the instant case, the instrument is used as an electron diffraction camera only the coil 7 is energized.

Interposed in the path of the electrons which travel along the axis A—A is a diaphragm 9, which has a beam-forming aperture 9a therein, and beneath the said diaphragm there is a specimen mount 11 to which a crystalline or other opaque specimen 11a is cemented, or otherwise affixed. As will hereinafter more fully appear, the diaphragm 9 is immovably supported, and the specimen mount 11 is adjustably supported, by a plug-like structure 13 which is removable as a unit from a bore or conduit 15 which extends through the instrument along an axis which is normal to the electron axis A—A.

Before proceeding with a description of the removable plug-like structure or holder 13 upon which the diaphragm 9 and specimen mount 11 are supported, attention is called to the fact that that part of the bore 15 which lies to the left of the electron axis A—A contains a slidably mounted cup-shape valve 17 which may be moved inwardly to a position whereat its leading circular edge abuts a similarly shaped gasket 19 on the inner end of a cylinder 21 within which the plug

13 is contained. The vacuum tight seal thus formed permits the plug 13 to be withdrawn from the cylinder 21 without breaking the vacuum in the electron conduit 3. In order to facilitate the removal of air from the confines of the cylinder 21, both the cylinder and the plug 13 therein may be provided with registered holes 23 and the body or housing of the microscope may be provided with a port (not shown) in line with the said holes, through which the air may be removed prior to opening the valve 17.

The cylinder 21 within which the plug or holder 13 is contained is held in the bore 15 by means of a gland bushing 25 which is provided with a number of circumferentially spaced screws 27 which engage screw holes in the casing of the microscope. A so-called "Woodruff key" 29 holds both the cylinder 21 and plug 13 against rotation. It will be observed that the rounded edge of the key 29 is received in a slot 31 on the outer surface of the plug 13 and that (as shown in Fig. 2) the said slot extends to the inner or leading end of the plug. Hence, the plug can be inserted within the cylinder 21 (and the cylinder within the bore 15) only when the slot 31 is in register with the key 29.

The holder or plug 13 which carries both the rigidly supported diaphragm 9 and the adjustable specimen mount 11 is held in the cylinder by means of a handwheel 33 which has a dependent externally threaded collar 33*a* which engages the complementarily threaded inner surface of the gland bushing 25. Torque applied in the clockwise direction to the handwheel 33 through its handles or spokes 35 serves to screw up the collar 33*a* in the gland bushing 25 and causes a compression force to be applied to a gasket 37 through an annulus 39 which is keyed against rotation on the surface of the plug 13 contiguous the inner periphery of the wheel.

The projecting portion of the plug 13 is provided, in addition to the handwheel 33, with three thumbwheels 41, 43 and 45, respectively, which operate to control the orientation of the specimen mount 11 with respect to the electron axis A—A of the microscope or diffraction camera 1. Exactly how these thumbwheels operate to effect such movements of the holder 11 will be apparent from the following:

The specimen mount 11 is removably affixed to the inner end of a flexible rod 47 which is supported within the plug 13 in a manner to permit of its being both rotated about and moved slidably along an axis which is substantially normal to the electron axis A—A. The axial movement of this rod 47 is controlled by the thumbwheel 41 and its rotary movement is controlled by the thumbwheel 43. An externally threaded splined sleeve 49 which is held on the outer end of the rod 47 by a washer and nut 51 serves to move the said rod to the left or to the right as determined by the direction in which the thumbwheel 41 is rotated. The wheel 43, on the other hand, imparts its rotary movement directly to the said rod 47 through a hub 53 upon which the said wheel is slidably splined.

The third thumbwheel 45 operates through a second slidably mounted rod 55 and a tiltable carriage 57 to impart a flexing force to the flexible rod 47 upon which the specimen mount 11 is affixed. The details of the tiltable carriage 57 are shown more clearly in the end view (Fig. 2) wherein this T-shape member is shown pivotally supported adjacent to its lower end between two ball bearings 59 and 59*a* contained in separate

inwardly extending slots 61 and 61*a* in the rigid platform or extension 13*a* of the plug 13 which supports the diaphragm 9. (In Fig. 2 the diaphragm 9 has been removed from its seat in the platform 13*a*, but see Figs. 1 and 3.) Two pointed screws 61 and 61*a*, seated in the platform 13*a*, confine the balls 59, 59*a* in their holes and urge them into frictional supporting engagement with the opposite sides of the upstanding base of the T. The upper rod 55 which controls the movement of this T-shape carriage 57 is received in a hole in the crossarm of the T and is secured therein by two oppositely extending set screws 65, 65*a*. The lower rod 47, upon which the specimen-holder 11 is mounted, has a sliding fit in a hole provided for the purpose in the base of the T, adjacent to its pivot point. It will thus be apparent that when the thumbwheel 45 is turned to move the control rod 47 axially (to the left or to the right, as viewed in Figs. 1 and 3), the carriage 57 will be tilted in the same direction on its pivot (i. e. the balls 59 and 59*a*) and, as a result, the lower rod 47 will have a flexing force applied thereto along the section thereof which passes through the lower end of the said carriage 57. The flexure in the rod 47 produced by the tilting movement of the carriage 57 is localized by reducing the diameter of the said rod adjacent to its leading end, as indicated at 47*a* (Fig. 1).

As the rod 47 is flexed the specimen-support 11 on the end thereof is tilted with respect to the electron axis A—A; hence, the portion of the specimen 11*a* which is presented to the electron beam may be changed at will simply by turning the thumbwheel 45 which controls the movement of the carriage 57. The axial and rotatable movements imparted to the flexible rod 47 by the thumbwheels 41 and 43, respectively, are substantially unaffected by the angular position of the carriage 57 and this makes it practical to provide calibrations on the periphery of each of the thumbwheels 41, 43, 45 to indicate the relative position of the specimen at any given moment.

It is, of course, important to prevent air from leaking into the electron conduit 3 through the specimen-holder 13 and, to prevent such leakage, vacuum tight seals of a special construction are provided where the slidable control rods 47 and 55 pass to the exterior of the instrument. Since these seals for the rods 47 and 55 are of duplicate construction, a description of one will serve as a description of both.

As shown in Fig. 1, the rod 55 passes through a grommet 67, a metal washer 69 and a coil spring 71 which are contained in a bore, provided for the purpose, in the body 13 of the holder. This bore communicates through a passageway 73 with a second bore 75 which will be understood to contain a filling of oil having a low vapor pressure. The grommet or gasket 67 is constituted of synthetic rubber (e. g. "neoprene" or "hycar") or other suitable elastic material; and in the instant case is kept lubricated by oil from the reservoir 75. If desired, the gasket may be constituted of rubber (synthetic) sponge containing a filling of oil, in which case the reservoir 75 may be omitted. In either case, the gasket 67 is maintained under constant pressure, which squeezes it into intimate contact with the rod 55, by the compression force applied through the slidable washer 69 by the spring 71. A second spring, about the leading end of the rod 55 and which bears against the tiltable carriage 57, has been found to contribute to the smooth op-

eration of the said carriage and shaft 55 but is not a necessary adjunct to the operation of the vacuum tight seal above described.

The shape or form of the specimen mount affixed to the end of the shaft 47 will ordinarily be dictated by the kind of specimen to be examined and by the type of instrument used in its examination. Thus, while the flat surfaced plate 11 shown in Fig. 1 is recommended as a support for a crystalline specimen whose surfaces are to be examined in an electron diffraction camera, when the specimen comprises a powder-like substance or a transparent object which is to be examined in a transmission type microscope the use of a foraminous support, such, for example, as the one shown in Fig. 3, is recommended.

In Fig. 3 a small metal screen 77 (which will be understood to contain the specimen embedded in a collodion or similar film, not shown) is supported in a removable cap 79 which is fitted over the end of a hollow fixture 81 on the end of the adjustable control rod 47. Other types and forms of fixtures and supports will suggest themselves to those skilled in the art of electron microscopy.

From the foregoing it will be apparent that the present invention provides an improved specimen-holder which is capable of being oriented in all directions without breaking the vacuum in any part of the instrument in which it is used, and is further characterized by its ease of assembly and by the simplicity and accuracy of its adjustments.

What is claimed is:

1. In an electron optical device having an electron axis, a flexible rod supported within said device and extending to the exterior thereof, said rod terminating at its inner end adjacent to said electron axis, a support for a specimen mounted on said flexible rod adjacent to the said inner end thereof, and means extending to the exterior of said device for causing a flexing force to be applied to said flexible rod whereby to tilt said specimen-support with respect to said electron axis.

2. In an electron optical device having an axis along which electrons travel in the form of a beam, a flexible rod mounted to permit of movement along its axis within said device, said rod extending to the exterior of said device and terminating at its inner end adjacent to said electron axis, a specimen-support mounted on said flexible rod adjacent to the said inner end thereof, means adjacent to the outer end of said rod for moving said rod axially whereby to move said specimen-support into and out of the path of said electron beam, and means extending to the exterior of said device for causing a flexing force to be applied to said flexible rod, whereby to tilt said specimen-support with respect to said electron axis.

3. In an electron optical device having an axis along which electrons travel in the form of a beam, a flexible rod mounted to permit of rotatable movement about and longitudinal movement along its axis within said device, said rod extending to the exterior of said device and terminating at its inner end adjacent to said electron axis, a specimen-support fixedly mounted on said flexible rod adjacent to the said inner end thereof, means operatively connected to said rod adjacent to its outer end for moving said specimen-support in the path of said beam and for rotating said support in said path, and separate means extending to the exterior of said device for causing a flexing force to be applied

to said flexible rod whereby to tilt said specimen-holder with respect to said electron axis.

4. In an electron optical device having an electron axis along which electrons travel in the form of a beam and a second axis which intersects said first mentioned axis, a flexible rod mounted within said device to permit of rotatable movement about and axial movement along said second mentioned axis, said flexible rod extending to the exterior of said device and terminating at its inner end adjacent to the point of intersection of said axes, a specimen-support fixedly mounted on said flexible rod adjacent to the said inner end thereof, means for moving said rod axially whereby to move said specimen-support with respect to the point of intersection of said axes, means for rotating said rod and hence said specimen-support about said second mentioned axis in the path of said electron beam, and means extending to the exterior of said device for applying a flexing force to said rod adjacent to its said inner end whereby to tilt said specimen-support with respect to said electron axis.

5. The combination with an electron optical device having a first conduit through which electrons pass from a source to a target and a second conduit which communicates with said first mentioned conduit, of a holder for adjustably mounting a specimen within said electronic device so as to be impinged by said electrons and operable to adjust the point of impact at any point on the surface of said specimens as well as the angle of incidence of said beam on the surface of said specimen, said holder comprising a plug-like structure adapted to be received within said second mentioned conduit and containing a flexible control rod terminating at its inner end adjacent to the point of intersection of said first and second conduits, a support for a specimen fixedly mounted on said control rod adjacent to the said inner end thereof and extending into said electron conduit when said plug is received within said second conduit, means adjacent to the outer end of said plug for moving said rod axially whereby to move said specimen-support across the path of said beam, means adjacent to said outer end of said plug for rotating said rod and hence said specimen-support in the path of said electron beam, and means operably connected to the inner end of said flexible rod and extending to the outer end of said plug for applying a flexing force to said rod whereby to tilt said specimen-support with respect to said electron beam.

6. In an electron optical device having an axis along which electrons travel in the form of a beam, a carriage supported for tiltable movement adjacent to said axis, a flexible rod supported adjacent to its inner end, for axial movement on said carriage and extending to the exterior of said electron optical device, a support for a specimen mounted on said flexible rod adjacent to the said inner end thereof, means exterior of said device for moving said flexible rod axially whereby to move said specimen-support into and out of the path of said electron beam, and separate means extending to the exterior of said device for tilting said carriage to flex said rod and thereby tilt said specimen-holder with respect to said electron axis.

7. In combination, an evacuated envelope containing a part to be oriented within said envelope, a rod-like member mounted for movement within said envelope and extending to the exterior

thereof for controlling the movement of said part, an elastic bushing about said rod, means for lubricating said elastic bushing, spring means for applying a compression force to said lubricated elastic bushing along a line which intersects said control rod and in a direction calculated to urge said bushing into intimate contact with said control rod whereby to maintain the vacuum in said envelope when said rod is moved, and means for moving said rod.

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