This invention relates to electron-optical instruments and particularly to improvements in adaptable specimen-holders for such instruments.

The invention and the problems and objects with which the invention is concerned are described in connection with the accompanying drawings, wherein:

Fig. 1 is a diagrammatic representation of a specimen-holder of the prior art, the axes of the drawing being marked with arrows to indicate the several ways in which the holder may be manipulated to achieve a desired orientation with respect to the electron beam of the instrument.

Fig. 2 is a view similar to Fig. 1 but showing, diagrammatically, the axes and directions of movement of the specimen-holder of the present invention.

Fig. 3 is an exploded view of a detachable holder for a plurality of transparent microscope specimens.

Fig. 4 is a view in perspective of a detachable holder for an opaque diffraction specimen.

Fig. 5 is a front elevational view, partly in section, showing the interior of an electron-optical instrument containing a specimen-holder and adjusting mechanism constructed in accordance with the principle of the present invention.

Fig. 6 is a fragmentary front elevational view with certain of the parts of Fig. 5 removed to reveal the tiltable parts of the adjusting mechanism of Fig. 5.

Fig. 7 is a partly broken-away plan view, partly in section, of the device of Figs. 4, 5 and 6.

Fig. 8 is a side elevational view, partly in section, looking in the direction of the arrow 8 in Fig. 5 and showing the mechanism for imparting a vertical movement and one (of the two) horizontal movements of the tri-part yoke of Figs. 5, 6 and 7.

Fig. 9 is a fragmentary view partly in section of the yoke end of the mechanism of Fig. 8.

Runge U. S. Patent No. 2,418,903, issued April 15, 1947, discloses a specimen-holder capable of being oriented in virtually all directions with respect to the electron-optical axis of a microscope, diffraction camera, or the like, without breaking the vacuum in the instrument. As shown diagrammatically in Fig. 1, Runge's specimen holder 1 is mounted to permit both direct axial and direct rotational movement about an axis a—a normal to the electron-optical axis x—x. The third or vertical movement (i.e., parallel to the axis z—z) in Runge's device cannot be achieved directly but only indirectly by means of a bowed support capable of tilting the mount (as indicated by arrow 2) about a virtual pivot 1 on the axis a—a, and then moving the pivot point axially, and if necessary, rotationally. The complicated nature of this latter adjustment limits, at the extent of all of the said movements to such a degree that, as a practical matter, the specimen-holder can not ordinarily be made large enough to accommodate more than one or two specimens at a time.

Accordingly, the principal object of the present invention is to provide an improved specimen-holder for use in electron-optical instruments and one which shall be free from the above described limitations to present-day adaptable specimen holders.

Another and specific object of the present invention is to provide a specimen-holder, and an adjusting mechanism therefor, having various discrete freedoms of movement and hence capable of moving the holder to a desired position without affecting any previously achieved setting or orientation of the holder.

As shown diagrammatically in Fig. 2, the specimen holder 2 is mounted in accordance with the present invention to permit it to be moved parallel to the electron-optical axis x—x (as indicated by the vertical arrows) as well as along and about separate axes a—a, b—b, at right angles to each other in a (vertically movable) plane normal to the optical axis. The manner in which these several movements are accomplished will be described in connection with the apparatus shown in Figs. 5 to 9 inclusive. However, before proceeding to the description of the adjusting mechanism per se, attention is called to the different specimen-type holders shown in Figs. 3 and 4.

The specimen holder shown in Fig. 3 is designed to carry a number (in this case, nine) of transparent microscope specimens and, to this end, comprises a small tray 1 having a corresponding number of apertures therein within which the specimens are discretely supported, each on a collodion film deposited in the usual way upon one of the spaced-apart removable fine-mesh screens 2 in the said holes. A removable apertured cover 3 is provided for holding the screens in their seats upon the tray. Tray 1 terminates at its inner end in a centrally disposed collar 4 which fits on the free end of a rotatable stub shaft 5 (Figs. 6 to 9) within the specimen chamber 6 of the instrument. As will hereinafter more fully appear, the adjusting mechanism is capable of presenting each one of the nine specimens, selectively, to the beam at any angle re-
quired to produce an electron micrograph of that specimen.

Referring to Fig. 4, in the event that the electron-optical instrument is to be used as a diffraction
camera, the tray 1 of the holder shown in Fig. 3 may be omitted and a crystalline or other
(usually opaque) specimen 5 may be cemented or otherwise affixed to the free end of a detachable
collar 4, similar to the one shown at 4 in Fig. 3.

As shown in Figs. 5 and 7, the specimen chamber 6 comprises simply the interior of a hollow
metal casting or other casing 7 which will be under-
stood to form a part of an evacuable column
surrounding the electron-optical axis $x-\bar{x}$ along
which electrons travel, in the form of a beam, from an "upper" source (not shown) to the speci-
men and thence to a "lower" fluorescent screen,
photographic plate or other target, (not shown).

The front of the casing 7 is provided with a
tight door 8 (Fig. 7) through which access may be
had to the interior of the chamber 6 for the
purpose of mounting an appropriate specimen
holder 9 or 10 (Figs. 3 and 4) on its support 11.
The door 8 contains a window 9 through which
the orientation of the specimen holder may be
observed when the door is closed. In the instant
case the casing 7 is also provided with a port
16 within which an auxiliary source of electrons
(not shown, but which may be similar to the
one described in copending application
Serial No. 10,084, filed February 21, 1948, now
Patent No. 2,467,224, of Picard) may be mounted
so that the low velocity electrons from the said
source impinge upon the specimen to prevent it
from "going positive" when subject to bombard-
ment by the high velocity electrons of which the
main beam is comprised.

As shown more clearly in Fig. 5 there is a bank
of five control knobs, 11 to 15 inclusive, mounted
on the exterior of the casing 6 as on a block 16,
convenient to the right hand of an operator look-
ing through the window 9 in the door 8. The
control shafts 11a-15a to which these knobs are
affixed extend through vacuum-tight bushings
17 (which may be of the type shown in Range
2,418,903, supra) into the chamber 6 where they
terminate each in a universal joint 11b-15b, re-
spectively, from which telescopic shafts 11c-15c
extend in the direction of the "cradle" upon
which the specimen-holder support 5 is mounted.
These telescopic shafts 11c-15c are in turn con-
nected to the various movable parts of the cradle
through universal joints 11d-15d respectively.

The cradle upon which the specimen-holder
support 5 is mounted comprises a nest of three
U-shape yokes 21, 22, and 23, which, in the instan-
tcase, are mounted upside-down at the "rear" of
the electron-optical axis $x-\bar{x}$ of the instrument.

As previously indicated, the specimen-holder
support 5 comprises the free end of a rotatable
shaft. This shaft 5 is journaled for rotation in
the base of the innermost yoke 20 and terminates,
adjacent to its rear end, in a driven gear 23. The
driving gear for this driven gear 23 comprises a
worm gear 24 which is conveniently supported for
rotation on a small bracket 25 (Figs. 7 and 8)
on the rear of the yoke 20. The worm 24 and
hence the driven gear 23 and shaft 5 are con-
nected in torque-transfer relation with the knob
11, on shaft 11a, through the universal joints
11b and 11d at opposite ends of the telescopic
shaft 11c. Thus, upon turning the knob 11 clock-
wise or counterclockwise the support 5, and hence
the specimen-holder thereof will be rotated in
the corresponding direction as viewed by an ob-
server at the front of the instrument looking
through the window 9.

The smallest or innermost yoke 20 is supported
on a rod 26 for lateral movement in the space
between downwardly extending arms of the
second or intermediate yoke 21. The force re-
quired to move the innermost yoke 20 (and hence
the specimen-holder support 5, thereon) to the
left or to the right (as viewed in Figs. 5 and 7)
is applied to it through a lead screw 27 which ex-
ten through a nut 28 fixed on the inverted base
of said yoke. The lead screw, in turn, is driven
by torque applied to the knob 12 and transmitted
to said screw through the straight shaft 12a, the
telescopic shaft 12c and the universal joints 12b
and 12d.

The second or intermediate yoke 21 is supported
intermediate its ends on pivots 29 mounted be-
tween the parallel arms of the outermost yoke
22. As shown more clearly in Fig. 6, the inter-
mediate yoke 21 is biased to its upright position
by means of a coil spring 30 which is connec-
ted to yoke 21 and, at its other end, to an arm 32 on
the outermost yoke 22. The yoke 21 (and hence
the yoke 20 and the specimen-holder support 5 there-
on) may be tilted against the biasing force of
the spring 30 by means of a threaded plunger 33
which bears against an inclined surface 34 (Fig.
6) on said yoke and extends through a comple-
mentarily threaded bushing 35 secured to the
right arm of the outermost yoke 22. The rotary
force required to move the plunger 33 in-and-out
is applied through the knob 13 which is connected
at the said plunger through the straight shaft
13a, the telescopic shaft 13c and the universal
joints 13b and 13d at the opposite ends of the shaft
13c.

The largest or outermost yoke 22 is not subject
to the tilting force applied to the intermediate yoke
21 nor to the left-and-right movement ap-
piled to the innermost yoke 20, but is mounted
to permit of forward and rearward movements
(with respect to the observer) and vertical (up-
and-down) movement (i.e., parallel to the elec-
tron-optical axis $x-\bar{x}$ of the instrument).

The mechanisms through which these latter move-
ments are effected are shown more clearly in Figs.
7 and 8.

It will be observed upon inspection of Figs. 7 and
8 that the outermost yoke 22 is provided on its
rear surface with a rearwardly extending arm
40 which carries a horizontally disposed rack 41
on its upper surface and a mounting block 42
adjacent to one side of the free end of the rack.

The mounting block is splined, as indicated at
43 (Fig. 7) for vertical movement in arm 40 which
extends inwardly from the rear wall of the
chamber 6 a distance sufficient to provide a clear-
ance space for the rearward movement of the
horizontal rack 41. The block 42 has two pinions
45 and 46 provided with rack 41 adjacent to one
side of the free end of the rack.

The pinion 45 is provided with rack 41 serves to
impart forward and rearward movement to the yoke 22 (and hence to the other yokes 20 and
21, and the specimen-holder support 5) through the rack 41.

The other pinion 46 meshes with the teeth on
a second rack 47 (Fig. 8) which is rigidly sup-
ported in an upright position upon a stationary
When the second pinion 46 turns in its bearing on the vertically movable block 42, it carries the said block (and hence the horizontal rack 41 and the parts which are supported thereon) upwardly or downwardly as determined by its direction of rotation. The force required to actuate this pinion 46 is applied through the lever arm 48 of the bracket 44. As shown in Fig. 5, the vertical position of the specimen with respect to a fixed point on the electron-optical axis $x$ may be ascertained by reference to a cursor or scale 50, fixed on the left leg of the yoke 22 and arranged to be read in conjunction with a stationary scale 51 supported on the bracket 52 (Fig. 7) within the specimen chamber 6. This indicator 50-51 is of especial utility when the instrument is used as an electron-diffraction camera, since the setting required to achieve a particular size or spacing of the diffraction rings can be easily duplicated by reference to the indicator-reading.

From the foregoing detailed description of a preferred embodiment it will be apparent that the present invention provides, in combination: an electron-optical device having an axis (2-2) along which electrons travel, a shaft 49 having an axis of rotation and comprising a support for a specimen-holder mounted for movement within said device adjacent to said electron-axis, means (rack 41) for moving said shaft in a first direction parallel to said electron-axis, means (rack 31) for moving said shaft in a second direction (e.g., "forward or backward") normal to said first-mentioned direction, means (lead screw 27 and nut 28) for moving said shaft in a third direction (e.g., "left-or-right") normal to said first and second directions, means (gear 23 and worm 24) for tilting said shaft in a fourth direction irrespective of the position to which it has been moved in said first and second directions, means (inclined surface 34 and plunger 33) for tilting said shaft in a fourth direction irrespective of the position to which it has been moved in said first, second and third directions, and means (gear 23 and worm 24) for rotating said shaft irrespective of the position to which it has been moved in said first, second, third and fourth directions. In carrying the invention into effect it has been found that the adjusting mechanism can handle any type of specimen or conventional group of specimens when the straight-line movements of the mechanism are about one-inch in extent. Similarly, it has been found that the degree of tilt imparted to the holder seldom need exceed 6°, nor is it ordinarily necessary to make its angle of rotation exceed 180°.

It will be understood that the foregoing description of a preferred practical embodiment of the invention should be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an electron-optical device having an axis along which electrons travel, a shaft having an axis of rotation and comprising a support for a specimen-holder mounted for movement within said device adjacent to said electron-axis, means for moving said shaft in a direction parallel to said electron-axis, and means for rotating said shaft irrespective of the position to which it has been moved parallel to said axis.

2. The invention as set forth in claim 1 wherein said specimen-holder shaft is mounted within an evacuable specimen chamber and said shaft-moving and shaft-rotating means are provided with separate actuating mechanisms which extend to the exterior of said evacuable chamber.

3. The invention as set forth in claim 2 wherein at least one of said actuating mechanisms comprises a control shaft mounted for rotation in a wall of said chamber and provided with a universal joint on its inner end, a telescopic shaft connected to said rotatable shaft through said universal joint, and a second universal joint connected at one end to the inner end of said telescopic shaft and at the other end to the means for moving said specimen-holder shaft.

4. In an electron-optical device having an axis along which electrons travel, a shaft having an axis of rotation and comprising a support for a specimen-holder mounted for movement within said device adjacent to said electron-axis, means for moving said shaft in a first direction parallel to said electron-axis, means for moving said shaft in a second direction substantially normal to said first-mentioned direction, and means for rotating said shaft irrespective of the position to which it has been moved in said first and second directions.

5. In an electron-optical device having an axis along which electrons travel, a shaft having an axis of rotation and comprising a support for a specimen-holder mounted for movement within said device adjacent to said electron-axis, means for moving said shaft in a first direction parallel to said electron-axis, means for moving said shaft in a second direction substantially normal to said first-mentioned direction, means for moving said shaft in a third direction normal to said first and second directions irrespective of the position to which it has been moved in said first and second directions, and means for rotating said shaft irrespective of the position to which it has been moved in said first, second and third directions.

6. In an electron-optical device having an axis along which electrons travel, a shaft having an axis of rotation and comprising a support for a specimen-holder mounted for movement within said device adjacent to said electron-axis, means for moving said shaft in a first direction parallel to said electron-axis, means for moving said shaft in a second direction substantially normal to said first-mentioned direction, means for moving said shaft in a third direction normal to said first and second directions irrespective of the position to which it has been moved in said first and second directions, and means for rotating said shaft irrespective of the position to which it has been moved in said first, second and third directions.

7. The invention as set forth in claim 6 wherein said shaft is contained in an evacuable specimen-chamber and wherein each of said means for moving said shaft is provided with a separate actuating mechanism which extends to the exterior of said evacuable chamber.

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