April 20, 1948. I. B. BENSEN 2,440,067

MANIPULATOR

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Fig. 1.

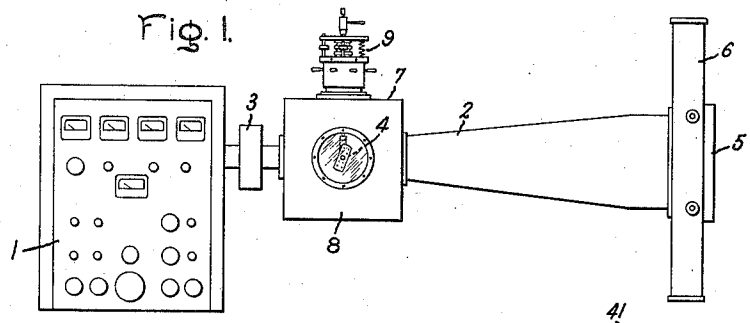


Fig. 2.

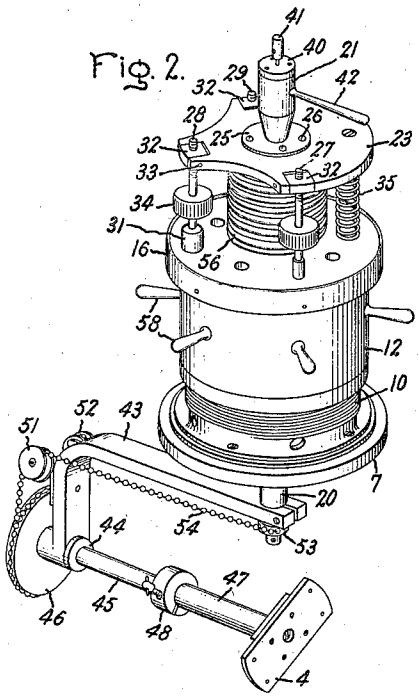
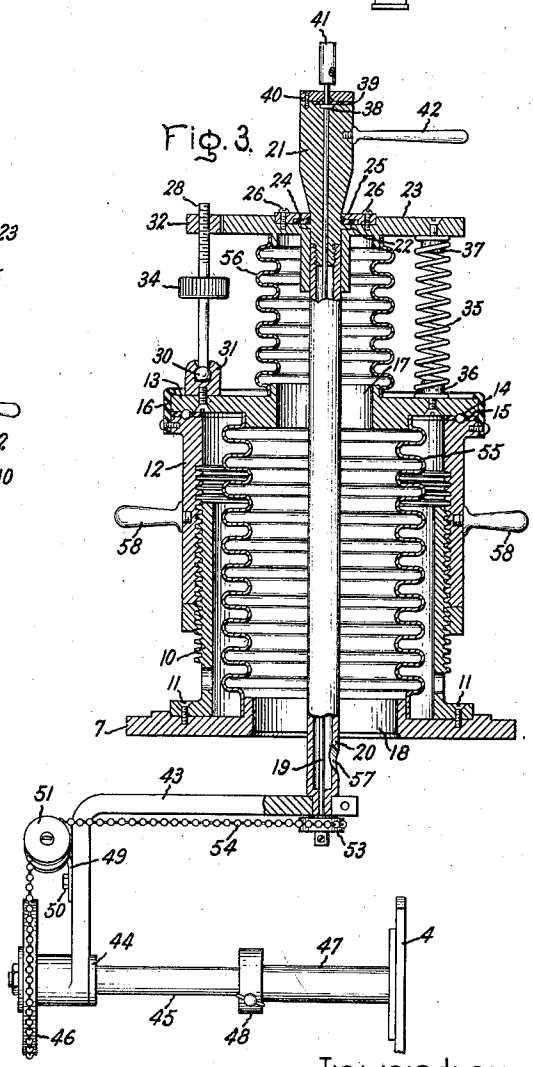


Fig. 3.



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MANIPULATOR

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10 Claims. (Cl. 250—49.5)

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My invention relates to positioning means and, more particularly, to devices for manipulating or controlling the position of an article.

It is frequently desirable, for example in microscopy, to control the position of an article or element to be examined. Thus, in electron optical instruments, for example an electron diffraction instrument, it is desirable to control not only the position of an article or specimen to be examined, but it is also important that the specimen be capable of being moved in various independent directions to control the point of incidence of an electron beam, as well as the angle of incidence of that beam on the specimen. It is, furthermore, important to provide mechanisms which permit precise and minute adjustment of the specimen position through three degrees of translation and two degrees of rotation and which obtain such manipulation without involving complex mechanisms. Thus, it is desirable not only to reduce the expense of manufacturing such mechanisms, but also to maintain the size as small as possible so that it is not large and cumbersome in comparison with the specimen to be examined, particularly since in such work the manipulator usually is maintained within an evacuated vessel or container. It is desirable that the dimensions be as small as possible to reduce the time and cost of evacuating the apparatus.

It is an object of my invention to provide a new and improved positioning device or manipulator.

It is another object of my invention to provide a new and improved positioning device or manipulator which is simple in construction and arrangement and which is capable of precisely positioning an object to be investigated in three degrees of translation and two degrees of rotation.

It is a further object of my invention to provide a new and improved manipulator comprising two coaxial shafts which are independently rotatable and the axis of which may be varied precisely to position a specimen relative to three degrees of translation and two degrees of rotation.

Briefly stated, in the illustrated embodiment of my invention, I provide a manipulator or positioning device for controlling and holding an article or object and which is susceptible of producing rotation about two angularly disposed axes and the common axis of which is variable in position so that the position of a supported article may be controlled precisely through three mutually perpendicular directions of translation as well as two degrees of rotation.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the

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appended claims. Fig. 1 is a side elevation view of an electron diffraction instrument suitably embodying the invention. Figs. 2 and 3 are perspective and vertical sectional views, respectively, of the manipulator employed in the instrument of Fig. 1.

Referring now to Fig. 1, there is shown a portion of an electron diffraction instrument which comprises a control panel 1 behind which is located an electron gun, not shown, for projecting a beam of electrons through an evacuated tube 2. The electron beam is focussed by means of a focussing yoke 3, which may be of the magnetic type, to fall upon a specimen to be examined and supported on a suitable article carrier 4. The electron beam may either be reflected from the specimen or may be allowed to pass through the specimen, if it is a very thin one, to form a diffraction pattern upon a fluorescent screen 5. Alternatively, the pattern may be formed upon a photographic plate or film located within an evacuated film holder 6. The specimen holder 4 is arranged within a specimen chamber 7 having a hinged door or entrance 8. Since, in the study of the crystalline structure of a specimen being examined it is desirable to control the point of incidence of the electron beam on the specimen, as well as the angle of incidence in the case of a reflected beam, a manipulator or positioning means 9 is provided for varying the position of the specimen support 4 through two degrees of rotation and three degrees of translation.

Referring now to Figs. 2 and 3 jointly, the manipulator 9 is illustrated as comprising a cylindrical casing 10 which is adapted to be secured to the upper surface of the specimen chamber 7 by a plurality of screws 11. The casing 10 is externally threaded and is surrounded by an internally threaded cylinder 12. A plate member 13 is supported on the upper surface of the cylinder 12 by a ball bearing 14, the race of which may be formed integrally in the upper surface of the cylinder 12 and the lower surface of the plate 13. A retaining ring 15 for the ball bearings 14 is interposed between the adjacent surfaces of the members 12, 13. The members 12, 13 may be held in assembled position by an assembly ring 16 which is adapted to be screwed to the cylinder 12.

The plate 13 and the upper surface of the specimen chamber 7 are provided respectively with aligned apertures 17, 18 through which extend a pair of coaxial shafts 19, 20. The shaft 20 is hollow and its upper end is attached, as by threads, to an externally accessible shaft 21. The shaft 21 in turn, is provided with a shoulder 22 which is supported in a recess in a mounting plate 23. A sealing arrangement is provided around the shoulder 22 and comprises a gasket

24 formed of a suitable material, such as rubber, and a retaining ring 25 which is attached to the mounting plate 23 by a plurality of screws 26. The mounting plate 23, in turn is supported from the upper surface of plate 13 by three vertical adjusting screws 27, 28, 29. The manipulating screws 27—29 at their lower ends are formed with ball surfaces 30 which are retained in races 31 attached to the upper surface of plate 13. At their opposite ends, each of the screws 27—29 engages a nut 32 which is pivotally supported in the mounting plate 23 by a pin 33. Intermediate their ends, each of the screws 27—29 is provided with a knurled boss 34. Diametrically opposite the screw 28 there is positioned a compressed spring 35 which is attached to the plates 13, 23, respectively, by attachment devices 36, 37. The shaft 19 is likewise journalled in the member 21 by a sealed bearing which comprises a shoulder 38, a rubber gasket 39, and a retaining ring 40. The shaft 19, at its upper end, is provided with a knob 41 whereby it may be rotated independently from the shaft 20. Likewise the shaft 20 may be rotated by means of a handle 42 attached to the member 21.

There is provided a frame member 43 which is attached to the shaft 20 at its lower end and adapted to be rotated thereby. The frame member 43 is L-shaped and includes a vertical section which is terminated in a bearing 44. Journalled in the bearing 44 is a shaft 45 which bears, at its left-hand end, a gear 46. Arranged to slide over the right-hand portion of the shaft 45 is a sleeve member 47 which, at its outer end, supports the specimen carrier 4. The sleeve member is adjustable on the shaft 45 and may be clamped thereto by means of a clamping ring 48. Supported on the vertical section of the L-shaped frame member 43 is a strap member 49 which may be attached to the member 43 by any suitable arrangement, such as the bolt 50, and which serves as a support for two idler pulleys 51, 52. Means are provided for rotating the shaft 45 and the plate 4 and comprise a driving pulley 53 which is attached to the lower end of the shaft 19 and which is provided with a plurality of sockets for receiving a ball chain 54. The ball chain 54 is arranged to pass over the idler pulleys 51, 52 and drive the socketed gear 46. Preferably, the strap 49 is slotted so that it functions as a take-up device to adjust tension in the driving chain 54.

As previously pointed out, the manipulator thus far described is particularly adapted for use in evacuated electronic optical equipment and, to that end, I provide a pair of Sylphon bellows 55, 56 sealed, respectively, between the outer surface of the specimen chamber 7 and the lower surface of the plate 13 and between the upper surface of the plate 13 and the mounting plate 23. The bellows 55, 56 may be sealed at their respective ends to vertically extending flanges provided on the respective surfaces by any suitable means, such as a solder. Likewise, in order that all gases may be evacuated from portions of the manipulator within the evacuated region, the shaft 20 is provided with a lateral opening 57.

In the operation of the manipulator described to position an article or specimen supported on the carrier 4, rotation of the shafts 20, 21 by means of lever 42 operates to rotate the arm 43 supporting the carrier 4 about the axis of the shafts 19, 20. Rotation of the shaft 19 by means of the externally accessible knob 41 operates to rotate the gear 46 and the carrier 4 about the axis of the shaft 45. As shown, this axis is substantially at right angles to the common axis of the shafts 19, 20. However, for a particular design, the axis of the shaft 45 may be inclined at any desired angle with respect to the common axis of the shafts 19, 20. Means are provided for moving the frame 43 and the carrier 4 in a direction parallel to the axis of the shafts 19, 20 and comprise the capstan bars 58 which screw the cylinder 12 on the casing 10, either compressing or expanding the Sylphon bellows 55, depending upon the direction in which the cylinder 12 is rotated. Thus, rotation of the cylinder 12 produces translation of the carrier 4 along the axis of the shafts 19, 20. Translation in any direction in the longitudinal plane, as well as further translation along the common axis of the shafts 19, 20, is provided by the screws 27—29. It is readily apparent that, by manipulation of these screws, not only may the carrier 4 be moved along the axis of the shafts 19, 20, but also leveling in any plane perpendicular to this axis may be obtained. The spring 35 resists such motions of the assembly by the screws 27—29, thus providing a universal type of motion for the mounting plate 23.

The principal advantage of the position device which I provide is the facility with which the angle of incidence of an electron beam on a specimen supported on the carrier 4 may be varied. Thus, by simply rotating the shaft 20, the angle of incidence may be changed. Likewise, by simple rotation of the member 41, the carrier 4 may be rotated about the axis of the shaft 45.

Another advantage of the manipulator is the ability to accommodate specimens of different size. Thus, the sleeve 47 telescopes the shaft 45 so that specimens of different size may be supported on the carrier 4 and arranged so that the surface thereof lies in the path of the electron beam. Many minute changes in grazing angle or angle of incidence likewise are effected by the level arrangement provided by the screws 27—29.

My improved type of positioning mechanism likewise offers decided advantages in evacuated systems due to the fact that the total mechanism is relatively compact thereby reducing the time required to evacuate the associated apparatus and the fact that the entire manipulation may be observed and easily controlled.

While I have shown and described my invention as applied to a particular device, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention. I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a device for controlling the position of an article, the combination including a pair of coaxial shafts, means supporting said shafts, a frame member supported by one of said shafts for rotation thereby about a first axis, article supporting means including a shaft supported by said member and arranged to be rotated by the other of said shafts about an axis inclined at an angle to said first axis, and means for varying the position of the axis of said pair of shafts relative to said shaft supporting means.

2. In a device for controlling the position of an article, the combination including a pair of coaxial shafts, means supporting said shafts, a

frame member supported by one of said shafts for rotation thereby about a first axis, article supporting means including a shaft supported by said member and arranged to be rotated by the other of said shafts about an axis inclined at an angle to said first axis, means for varying the position of said frame member along the axis of said pair of shafts, and means for varying the position of the axis of said pair of shafts relative to said shaft supporting means.

3. In a positioning device, the combination comprising a pair of coaxial shafts, means supporting said shafts, an article supporting member supported by one of said shafts and arranged to be rotated about a first axis thereby, means including a shaft mechanically connected to the other of said pair of shafts for rotating said article supporting member about an axis inclined at an angle to said first axis, and means for varying the position of the axis of said pair of shafts relative to said shaft supporting means.

4. In a positioning device capable of providing rotating motions along two non-parallel axes, the combination comprising a pair of coaxial shafts, means for supporting said shafts, a frame member supported by one of said shafts and arranged to be rotated thereby, an article supporting member journalled in said frame member, means mechanically linking the other of said shafts and said article supporting member for rotation about an axis inclined at an angle with respect to the common axis of said pair of shafts, and means for varying the position of the axis of said pair of shafts with respect to said supporting means comprising a pair of independently adjustable members interposed between said supporting means and said pair of shafts.

5. A positioning device comprising a pair of coaxial shafts, means for supporting said shafts, a rod supported at one end of said shafts and inclined at an angle to the axis thereof, article supporting means supported on said rod, means for moving said rod longitudinally of said axis, means utilizing one of said shafts for rotating said article supporting means about the axis of said rod, and means utilizing the other of said shafts for rotating said article supporting means about the axis of said shafts.

6. A positioning device comprising a pair of coaxial shafts, means for supporting said shafts, a rod supported at one end of said shafts and inclined at an angle to the axis thereof, article supporting means supported on said rod, means for moving said rod longitudinally of said axis, means utilizing one of said shafts for rotating said article supporting means about the axis of said rod, means utilizing the other of said shafts for rotating said article supporting means about the axis of said shafts, and means for varying the position of the axis of said pair of shafts relative to said shaft supporting means.

7. In a device for controlling the position of an article within an evacuated enclosure, the combination comprising a pair of coaxial shafts extending within said enclosure, means including a resilient portion for supporting said shafts, said shafts having respective externally accessible parts, means for compressing said resilient portion to vary the axial position of said shafts, means for controlling the angular position of said shafts relative to their axis, article supporting means supported by one of said shafts at a point remote from the externally accessible part thereof, means utilizing the externally accessible part of one of said shafts for rotating said article supporting means about the axis of said shafts, and means utilizing the externally accessible part of the other of said shafts for rotating said article supporting means about an axis inclined to the axis of said shafts.

8. In an electron optical instrument having an evacuated chamber, a positioning means comprising a pair of coaxial shafts extending within said chamber, said shafts having externally accessible parts, article supporting means supported by one of said shafts within said chamber, said chamber including a movable portion, means for controlling the position of said movable portion to translate said shafts along the axis thereof, means for controlling the angular position of said shafts relative to said axis, means including one of said externally accessible parts for rotating said article supporting means about the axis of said shafts, and means including the other of said externally accessible parts for rotating said article supporting means about an axis inclined to the axis of said shafts.

9. In an electron optical instrument having an evacuated chamber, a positioning means comprising a pair of coaxial shafts extending within said chamber, said shafts having externally accessible parts, article supporting means supported by one of said shafts within said chamber, said chamber including a movable portion, means for controlling the position of said movable portion to translate said shafts along the axis thereof, means for controlling the angular position of said shafts relative to said axis, means including one of said externally accessible parts for rotating said article supporting means about the axis of said shafts, means including the other of said externally accessible parts for rotating said article supporting means about an axis inclined to the axis of said shafts, and means whereby the position of said article supporting means may be varied along said inclined axis.

10. In a positioning device for an electron optical instrument of the type having an evacuated chamber, the combination comprising a pair of coaxial shafts extending into said chamber, a bellows surrounding said shafts and sealed to said chamber, whereby a portion of said shafts is maintained at the pressure within said chamber, said shafts having externally accessible parts, article supporting means supported by one of said shafts within said chamber, means for compressing said bellows to vary the position of said shafts along their axis, and means utilizing said externally accessible parts for rotating said article supporting means about the axis of said shaft and an axis inclined thereto.

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