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CORPUSCULAR RAY DEVICE HAVING A SHIFTABLE SPECIMEN STAGE

Filed July 11, 1967

2 Sheets-Sheet 1

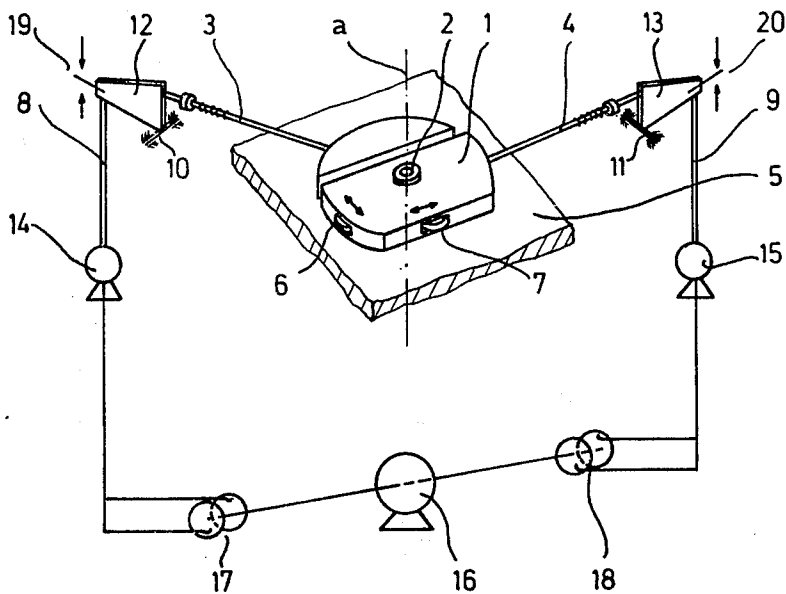


Fig. 1

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Fig. 2

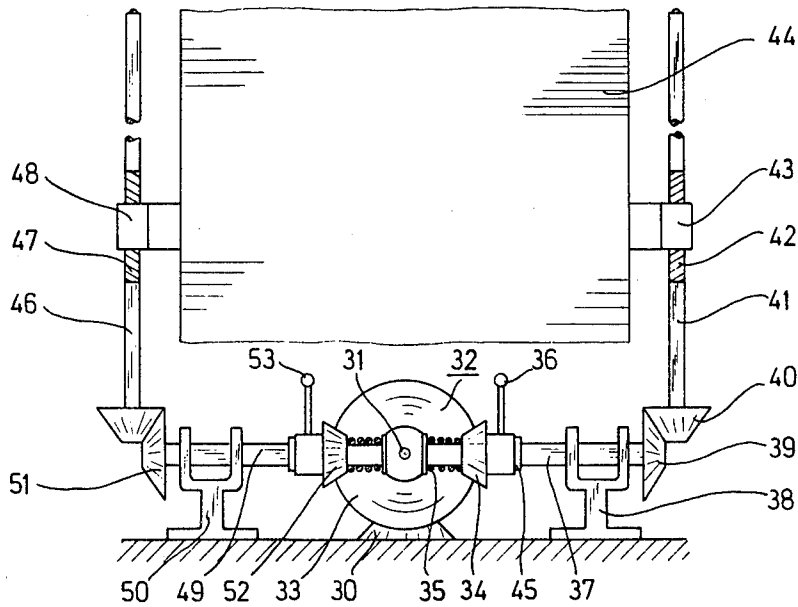
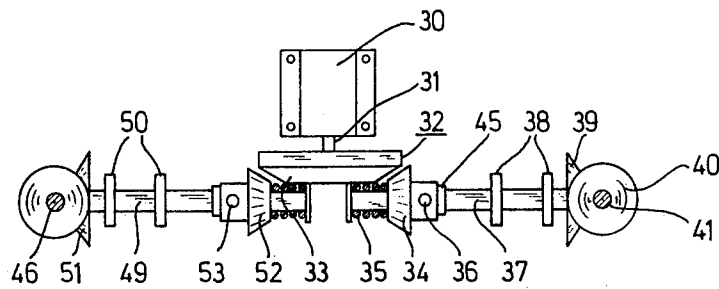


Fig. 3



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CORPUSCULAR RAY DEVICE HAVING A SHIFTABLE SPECIMEN STAGE

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5 Claims 10

ABSTRACT OF THE DISCLOSURE

A corpuscular ray device, such as an electron microscope, which is adapted to operate at substantially less than atmospheric pressure and which has a housing in which is located a specimen stage for supporting the specimen which is under investigation. The specimen stage is capable of being shifted in a pair of mutually perpendicular directions by a pair of adjusting rods which respectively extend in a fluid-tight manner through the wall of the housing of the corpuscular ray device from the interior to the exterior thereof, and these rods extend in mutually perpendicular directions and coact operatively with the specimen stage for shifting the latter in mutually perpendicular directions in response to longitudinal shifting of these adjusting rods. A remote-controlled adjusting motor means is operatively connected with the adjusting rods for longitudinally shifting the latter so as to bring about the shifting of the specimen stage in mutually perpendicular directions, and the circuit which energizes the adjusting motor means preferably includes contacts of a program-control means which brings about opening and closing of the circuit of the adjusting motor means according to a preselected program for producing sequential scanning of all specimen positions in a predetermined sequence.

Our invention relates to corpuscular ray devices, particularly to electron microscopes, which are adapted to operate, as by being operatively connected with a suitable vacuum pump assembly, at substantially less than atmospheric pressure. Our invention is also applicable to corpuscular ray devices other than electron microscopes, such as ion microscopes or electron diffraction devices.

Our invention relates particularly to those devices where a specimen stage is provided to receive the specimen which is to be investigated and where the specimen stage is shiftable in a pair of mutually perpendicular directions which are perpendicular to the axis of the corpuscular ray device by means of a pair of adjusting rods which extend in a fluid-tight, and thus vacuum-tight, manner from the evacuated interior of the housing of the device to the exterior thereof.

Known devices of this general type require manual operation of the adjusting rods, so that when adjustments of a predetermined region of the specimen which is under investigation are required, the operator must necessarily be situated directly at the microscope. Furthermore, with respect to the manual operations it is often inconvenient, when for the purpose of scanning the entire specimen the structure which is actuated by the operator, and which for the purpose of achieving very small specimen movements has very fine dimensions, must be adjusted by hand over a large range of movement.

It is thus a primary object of our invention to provide a structure which makes it possible to simplify the operations of a corpuscular ray device of this type, with respect to the movement of the specimen stage.

In particular, it is an object of our invention to sim-

plify these operations in such a way that remote controls are possible, so that, for example, it is possible for a lecturer at a speaker's pulpit to bring about adjustment of the specimen in the electron microscope during a lecture so that desired details of the specimen are enlarged.

Also, it is an object of our invention to provide a construction which makes it possible to scan the entire exterior surface, for example, of a specimen according to a predetermined program.

In accordance with our invention the corpuscular ray device is provided with a remotely controlled motor means for actuating the adjusting rods.

There are known corpuscular ray devices where the rotary movement of an adjusting spindle is converted into translational, longitudinal movement of a rod which coacts with the rotary spindle. With such a construction the adjusting motor means of our invention will provide the rotary movement of the adjusting spindle. In order to actuate both of the adjusting rods, it is only necessary to provide a single adjusting motor if this motor is capable of being operatively connected by a suitable clutch structure selectively with one or the other of the adjusting spindles.

For the purpose of automatically scanning a large part of the surface of the specimen, or the entire specimen, it is possible, when using a plurality of adjusting motors, to provide contacts of a program-control means in the energizing circuit of the adjusting motors, these contacts being actuated in such a way that they open and close the energizing circuit of the motors according to a preselected program which will provide for sequential scanning of all specimen positions according to a predetermined sequence.

Where the structure includes only a single adjusting motor which is common to both of the adjusting spindles, then for programming purposes the contacts of the program control means are arranged in the energizing circuit of the clutch structure for engaging and disengaging the clutch structure in such a way that through the clutch structure the adjusting motor is operatively connected with both spindles according to a preselected program which will provide for sequential scanning of all specimen positions according to a predetermined sequence.

The program-control means can take the form of an additional motor and contact cams driven thereby and arranged according to the predetermined program which is desired. In order to achieve a line-scanning pattern of the specimen it is also possible to make use of the movement of the specimen or the actuating structure which brings about this movement, by arranging in the program-control means a limit switch structure in the transmission between the adjusting motor and the specimen. Such limit switch structure brings about, when a predetermined position of the specimen is reached, a turning-off of one adjusting motor and a simultaneous turning-on of another adjusting motor. Where only a single adjusting motor is used, the limit switch structure will control the energizing circuit which brings about the engagement and disengagement of the clutch structure.

This clutch structure can take the form of friction clutches capable of being selectively brought into engagement with one or the other of the adjusting spindles.

The speed of operation of the different motors are suitably adapted to the particular degree to which the image is enlarged so as to harmonize with this degree of enlargement.

It is also possible, with a suitable choice of the operating speed, to permanently retain different specimen details photographically, for example on suitable film, during automatic scanning of a specimen according to a predetermined program.

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Our invention is illustrated by way of example in the accompanying drawing which forms part of this application and in which one embodiment of our invention is schematically illustrated.

FIG. 1 is a schematic illustration of a specimen stage, shown in perspective, with a diagram of the appertaining control means;

FIG. 2 is a front view of another embodiment of the invention; and

FIG. 3 is a top view of the same embodiment as shown in FIG. 2.

In FIG. 1, the specimen stage 1, which in the illustrated example receives a specimen held in a specimen cartridge 2, is shiftable by means of a pair of adjusting rod means 3 and 4 in opposition to the action of unillustrated counter-springs in a pair of mutually perpendicular directions both of which are perpendicular to the axis *a* of the corpuscular ray. This specimen stage 1 rests on the upper surface 5 of an objective lens which is not illustrated further and which forms the first imaging lens of an electron microscope, for example.

At its different lateral bearing surfaces the specimen stage 1 is provided with rollers of which the drawing illustrates only the rollers 6 and 7 which serve to support the specimen stage against the counter-springs.

The translational or longitudinal movement of the adjusting rods 3 and 4 is brought about in the illustrated example by way of rotary movement of threaded adjusting spindles 8 and 9 which are supported for rotary movement in suitable nuts, respectively. Thus, when the spindles are turned they will advance axially. The translational movement of the adjusting spindles 8 and 9 is converted into translational or longitudinal movement of the adjusting rods 3 and 4 by way of a pair of pivoted bell cranks 12 and 13 which are respectively supported by pivots 10 and 11 and which respectively engage both the spindles 8 and 9, on the one hand, and the adjusting rods 3 and 4, on the other hand, so that the axial movement of the spindles 8 and 9, in response to rotary movement thereof, is converted into horizontal longitudinal shifting movement of the adjusting rods 3 and 4 which respectively extend in mutually perpendicular directions in a vacuum-tight manner through the wall of the housing of the electron microscope from the interior to the exterior of this housing, so that the outer ends of the rods 3 and 4 are situated at the exterior of the evacuated atmosphere to be acted upon by the structure of our invention. Thus, the adjusting spindles 8 and 9 operate practically in the same way as plungers or rods on the bell cranks 12 and 13, respectively.

The rotary movement of the spindles 8 and 9 which is required to shift the specimen stage 1 is brought about, in accordance with our invention, by adjusting motors 14 and 15, which form an adjusting motor means. Thus, the motors 14 and 15 may drive, in any suitable way, vertically extending hollow drive shafts which respectively receive the spindles 8 and 9 which are respectively slidably keyed or splined to these hollow drive shafts so as to be constrained to rotate therewith while being longitudinally shiftable with respect thereto, and the threaded spindles 8 and 9 may extend threadedly through stationary nuts so that in response to turning of the spindles they will move axially to bring about the adjustment of the specimen stage.

In the illustrated example the adjusting motors 14 and 15 are alternatively controlled according to a predetermined program in such a way that by bringing about corresponding shifting movement of the specimen stage 1 according to a preselected program all specimen positions are sequentially shifted one after the other into the region of the corpuscular ray axis *a*, so that the entire specimen will be scanned. For this purpose a program control means is provided, and this program-control means includes an additional motor 16 as well as an energizing circuit for the motors 14 and 15, this energizing circuit including

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the contact assemblies 17 and 18 actuated by the additional motor 16 of the program-control means. As is schematically illustrated in the drawing, the motor 16 drives cam discs which actuate the contacts 17 and 18, these cam discs being mounted on the shaft of the motor 16, so that in this way it is possible to produce the desired program by a correspondingly timed sequence of movements of the specimen stage.

The program-control means can additionally include in the energizing circuits of the motors 14 and 15 limit switch means 19 and 20 which will also contribute to the controlled scanning of the specimen according to a predetermined program. Thus, for each adjusting rod means 3 or 4 there is situated in the transmission thereto, which includes the adjusting spindle 8 or 9 and bell crank 12 or 13, a limit switch means 19 or 20 which will limit the extent of movement of the specimen stage. Each of these limit switch means includes a pair of end contacts which are stationary and a movable contact located between the end contacts so that when the movable contact has advanced from one to the other of the end contacts the particular driving motor 14 or 15 will be turned off and the other driving motor will be turned on. Instead of being used in conjunction with the cam-actuated switches 17 and 18, the limit switches 19 and 20 may also be used separately to provide a different type of program. Thus by way of the limit switches 19 and 20 it is possible to turn the motors 14 and 15 on and off whenever the specimen stage has reached a predetermined position. The moveable contacts of the limit switches 19 and 20 are respectively carried by the bell cranks 12 and 13 for movement therewith between the stationary end contacts of the limit switches.

In order to initiate the programmed operation, the control motor 16 is started in an unillustrated manner, and, for example, after termination of the scanning of a specimen, it is automatically turned off.

FIGURES 2 and 3 show another embodiment of the invention, using only one adjusting motor 30, which bears on its axis 31 a plate 32 participating in the rotations of axis 31.

FIG. 2 shows a front view,

FIG. 3 a view from above.

As is clearly understood from the drawings, plate 32 has a conical front surface 33 acting as a friction drum together with the conical friction drum 34, if friction drum 34 is brought into action with said conical front surface 33 against the force of spring 35 by pushing lever 36 to the left. Thus, drum 34 is mounted on shaft 37 in a manner that allows sliding of drum 34 in the direction of the axis of shaft 37 but preventing drum 34 from rotation relative to shaft 37 as can be achieved by a key on shaft 37 extending into an axially disposed nut in drum 34.

Shaft 37 is held by holding means 38 allowing rotation of shaft 37 when drum 34 engages with conical surface 33. In this case, further conical friction drums 39 mounted on shaft 37 and 40 mounted on spindle 41 respectively cause rotation of spindle 41, which corresponds to spindle 9 in FIG. 1. As is clearly seen in FIG. 2, but not shown in FIG. 1, spindle 41 bears a thread 42 acting together with a thread inside holding part 43, which is fastened to column 44 of the corpuscular ray device, for instance an electron microscope. By these threads rotation of motor 30 and spindle 41 is converted into movement in the direction of its axis, i.e. up or down dependent on the direction of rotation of motor 30.

Spindle 41 acts on a pivoted bell crank, as is shown in FIG. 1 and designated with 13.

Thus, friction surface 33 and friction drum 34 are parts of clutching means for spindle 41. If lever 36 is not actuated, spring 35 pushes drum 34 against stop 45 on shaft 37.

There are further clutching means for spindle 46, having the same construction. Spindle 46 also bears a thread 47 coacting with holding means 48. There is also a shaft

49 held by holding means 50 and bearing conical friction drums 51 and 52, the first one corresponding to drum 39 and the second one to drum 34 respectively. Drum 52 bears lever 53. The method of operation is the same as described before, but lever 53 must be pushed to the right for engaging drum 52 with conical surface 33.

In this embodiment thread 47 is left-handed and thread 42 right-handed in order to ensure that rotation of plate 32 in one distinct direction causes the movement of both spindles 41 and 46 in the same direction.

We claim:

1. In an electron beam microscope having a movable specimen stage for holding a specimen and a device for shifting the specimen stage in two mutually perpendicular directions in a plane perpendicular to the beam, said device comprising two adjusting rod means mechanically engaging said specimen stage for respectively shifting the latter in two mutually perpendicular directions, two spindle rods mechanically engaging said two adjusting rod means respectively, a servomotor, a coupling for selectively connecting one of said two spindle rods to said servomotor whereby said servomotor transmits a rotating motion to said one spindle rod which in turn is translated into a rectilinear motion of the adjusting rod means mechanically engaged therewith, said coupling having an excitation circuit provided with contacts, and control means connected to said contacts for closing and opening the same whereby said coupling is selectively connected to said two spindle rods one at a time in accordance with a given sequence for shifting said specimen stage so as to permit all locations of the specimen to be scanned by the beam.

2. In an electron beam microscope having a housing, a movable specimen stage for holding a specimen and a device for shifting the specimen stage in two mutually perpendicular directions in a plane perpendicular to the beam, said device comprising two adjusting rod means

adapted to extend in an air-tight manner from the interior to the exterior of said housing and mechanically engaging said specimen stage for respectively shifting the latter in two mutually perpendicular directions, two servomotors mechanically connected to said two adjusting rod means respectively for moving the latter to shift the specimen stage, said servomotors having respective excitation circuits provided with contacts, and control means connected to said contacts for closing and opening the same whereby said servomotors are energized and deenergized in accordance with a given sequence for shifting said specimen stage so as to permit all locations of the specimen to be scanned by the beam.

3. The combination of claim 2 and wherein said control means includes an additional motor and contact cams driven thereby.

4. The combination of claim 2 and wherein said control means includes limit switches in the respective transmissions between said two servomotors and said specimen stage for limiting the movement of the latter in both of said mutually perpendicular directions.

5. The combination of claim 2 and wherein the electron beam microscope provides an enlarged image, and said motor means having an operating speed harmonizing with the degree to which the image is enlarged.

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