# United States Patent

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**Paris, France**
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[33] **France**
[31] **153,565**

[54] **VARIABLE-ORIENTATION MECHANISM**
**4 Claims, 5 Drawing Figs.**

[52] **U.S. Cl.** .......... **74/479,** 269/61, 269/71
[51] **Int. Cl.** .......... **G05g 11/00**
[50] **Field of Search** .......... 74/479; 269/61, 71; 250/49.5 B

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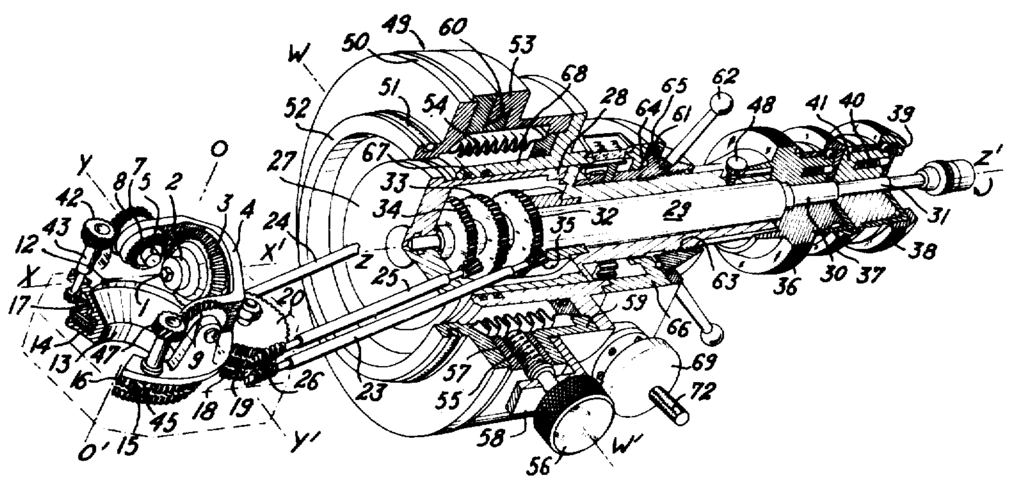
**ABSTRACT:** A variable-orientation mechanism which provides 6° of freedom for positioning samples. A sample-holder block is mounted to rotate about a first axis carried by a yoke which is pivoted about a second axis located at right angles to the first. The yoke is in turn carried by a support of revolution which rotates about a third axis located at right angles to the other two axes. The movements of the sample-holder about the three axes are controlled independently by a set of differential pinions and a movement produced by three concentric shafts carried by a support sleeve and driven in rotation by means of engageable operating knobs being transmitted to the differential pinions by means of a set of three rods having terminal helical screws. Means are additionally provided for displacing the support sleeve with respect to an outer cylindrical casing and independently in the direction of their common axis, in a direction at right angles to said axis and in rotation about said axis.



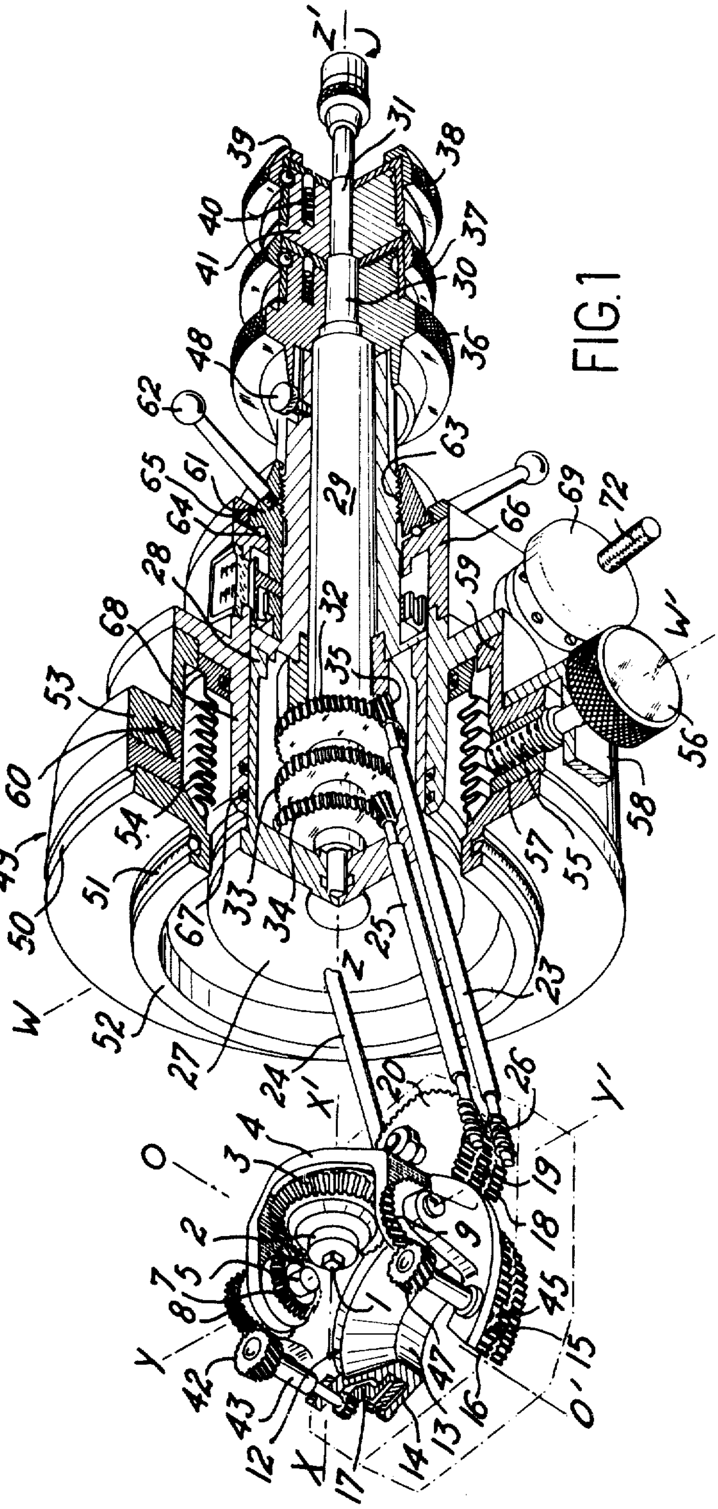

Z'
31
38
39
40
41
37
30
36
48
62
63
29
65
61
64
66
69
72
28
59
32
68
35
53
60
W'
56
58
57
55
54
49
50
51
33
34
67
25
23
Z
W
52
27
24
X'
20
26
Y'
O
3
4
19
18
9
2
5
7
8
1
45
15
47
Y
42
43
12
X
17
14
13
16
O'

FIG.1

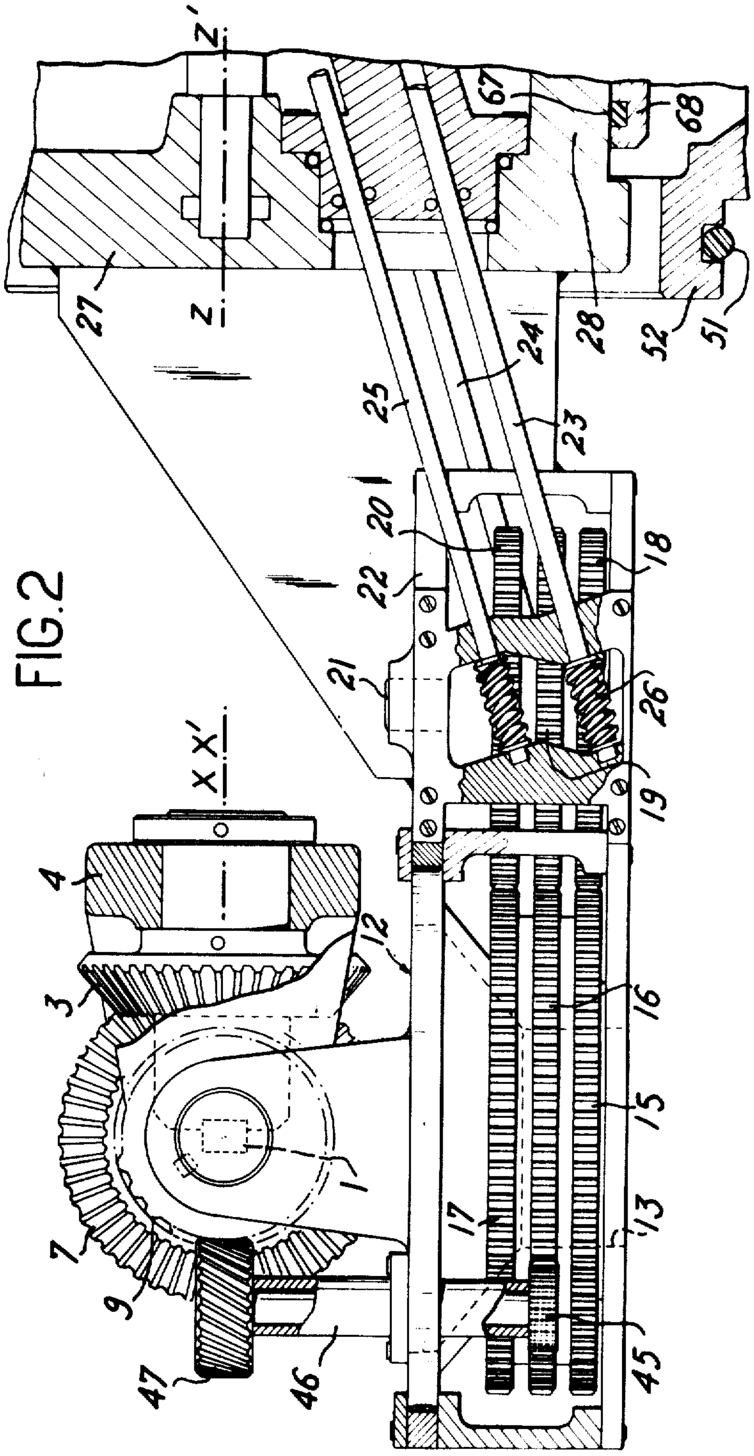

Z'
Z
27
67
68
28
52
51
24
25
23
20
22
18
21
26
19
X X'
4
12
3
16
15
1
13
17
7
9
45
46
47

FIG.2

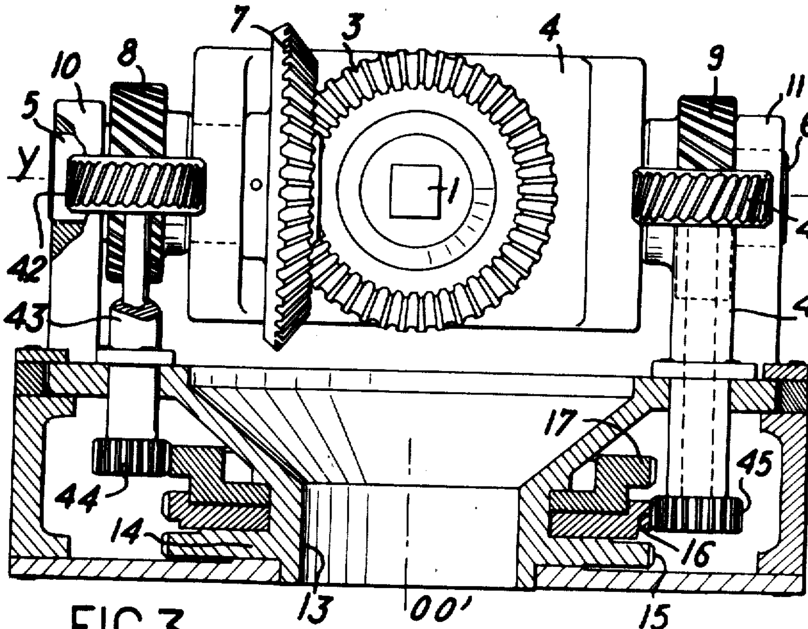

7
3
4
10
8
9
11
5
6
Y
Y'
1
42
47
43
46
17
45
44
14
16
13
00'
15

FIG.3

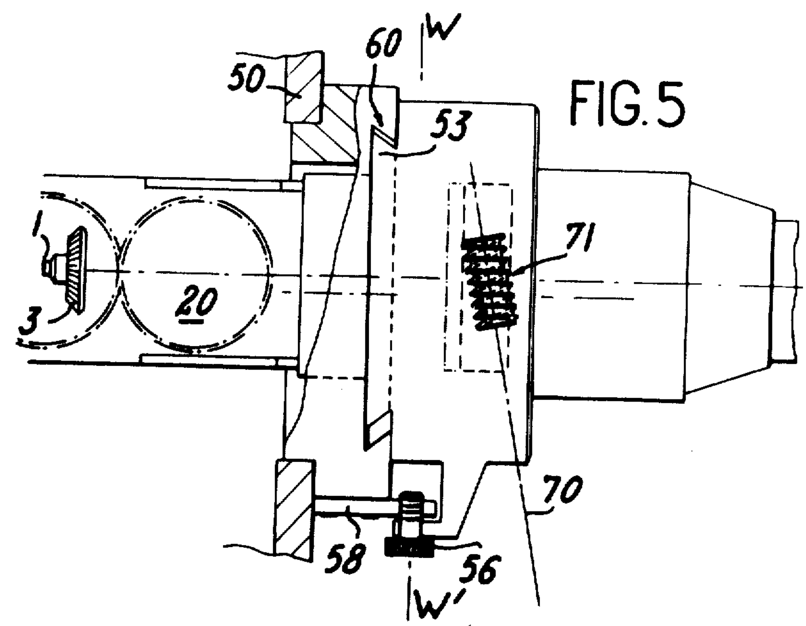

W
60
50
53
1
71
3
20
70
58
56
W'

FIG.5

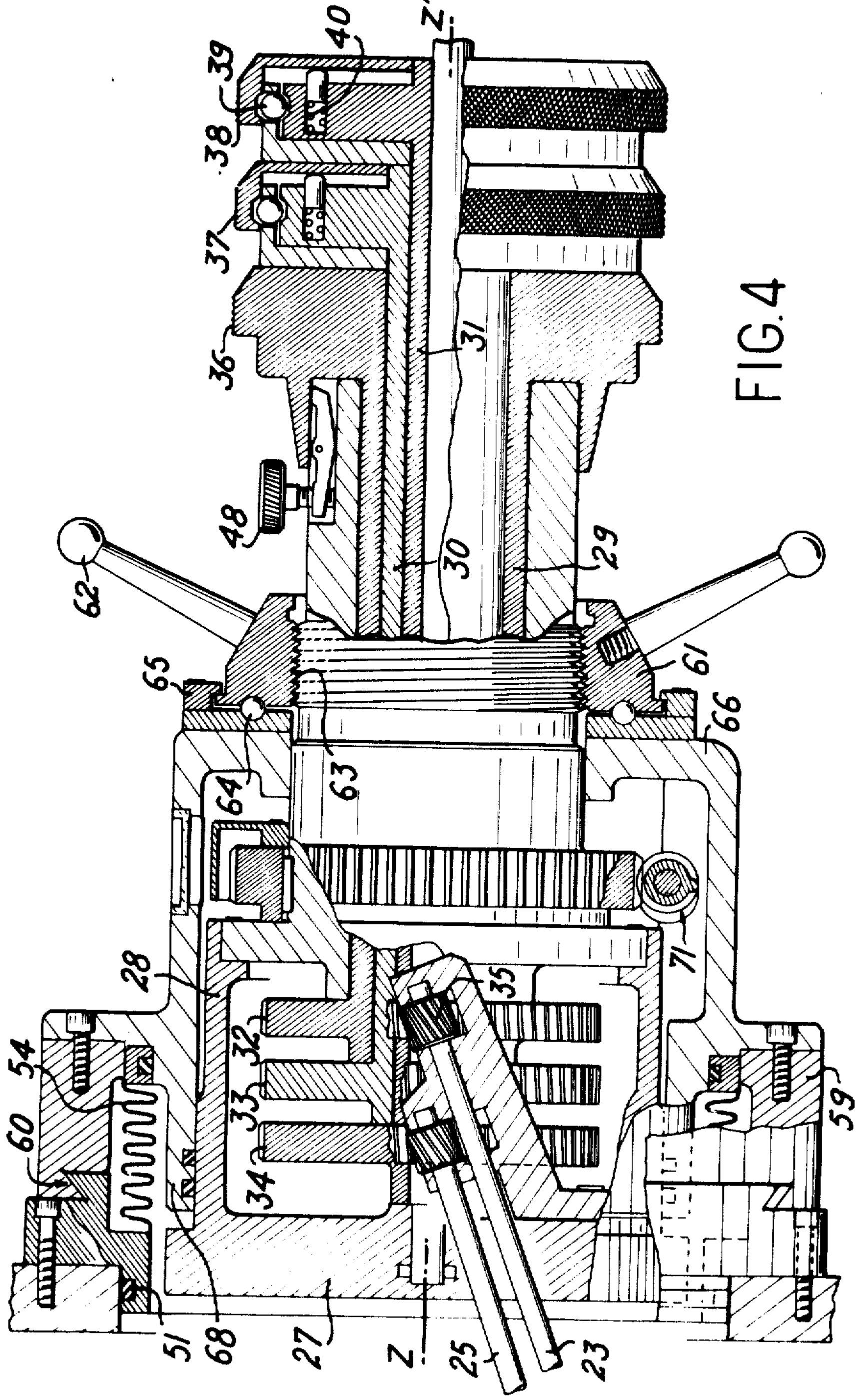

39
40
Z'
38
37
36
31
48
62
30
29
65
61
63
66
64
28
71
35
32
33
34
54
60
59
51
68
27
Z
25
23

FIG. 4

## VARIABLE-ORIENTATION MECHANISM

The present invention relates to a variable-orientation mechanism which can be employed more especially although not exclusively for the purpose of positioning a sample with respect to the direction of the beam of an electron diffractor.

In devices of this type which are already known, mechanical means for orienting a sample-holder are employed in combination with elements for heating or cooling this latter. The use of any magnetic or elctromagnetic means is precluded in order not to disturb the path of the electron beam. However, devices of this type have low precision and above all permit orientation of the sample only with a limited number of degrees of freedom which are usually four at a maximum.

This invention is directed to a variable-orientation mechanism whereby six degrees of freedom can be gained solely by mechanical means and with a remarkable degree of precision. To this end, said mechanism is characterized in that it comprises a sample-holder block mounted to rotate about a first axis carried by a yoke which is pivoted about a second axis located at right angles to the first, said yoke being in turn carried by a support of revolution adapted to rotate about a third axis which is located at right angles to the axes aforesaid, a set of differential pinions for controlling independently the movement of the sample-holder block about the three axes, a set of three rods provided at the extremities thereof with helical-thread screws for transmitting to the differential pinions a movement produced by three toothed wheels rigidly fixed to three concentric shafts carried by a support sleeve and driven in rotation by means of engageable operating knobs, a cylindrical casing formed of two parts and mounted coaxially with said sleeve and means for displacing said sleeve with respect to the casing independently in the direction of the common axis thereof, in a direction at right angles to said axis and in rotation about said axis.

There is thus achieved in the case of the sample-holder block a combination of orientations carried out with six degrees of freedom each defined separately from the others; said six degrees of freedom correspond on the one hand to three principal orientations with respect to the three first axes and on the other hand to three secondary orientations as defined by the position of the support sleeve with respect to its casing, said casing being stationary and constituting a reference which is common to the mechanism as a whole.

The following description which is given by way of indication without limitation illustrates a particular example of construction of an adjustable-orientation mechanism as constructed in accordance with the invention.

In the accompanying drawings:

FIG. 1 is a fragmentary view in perspective showing a mechanism of this type;

FIG. 2 is a view in elevation showing the sample-holder block and the complete assembly of differential drive pinions;

FIG. 3 is a side view of the same sample-holder block;

FIG. 4 is an axial sectional view of the support sleeve and of the support-sleeve casing;

FIG. 5 is a view on a smaller scale showing a detail of FIG. 4.

The first part of the description given hereinafter will relate to the constructional detail of the sample-holder block and of the means associated therewith for permitting the orientation of a sample with respect to three axes located at right angles to each other in space; a second part of the description will subsequently be concerned with the means for permitting the displacement of the sample-holder block as a whole with three additional degrees of freedom as defined by the directions of two perpendicular axes and by a rotation about one of said axes.

As is apparent from FIG. 1 and 2, the sample 1 is presented in the form of a small parallelepipedal element mounted on a cylindrical block 2 or sample-holder block, the axis X—X′ of which coincides with the axis of a bevel pinion 3 carried by a yoke 4 which is pivoted about a second axis Y—Y′, said second axis being located at right angles to the first and defined by two spindles 5 and 6. A bevel pinion 7 disposed in meshing engagement with the pinion 3 and a spur pinion 8 with oblique teeth coupled for rotation with the pinion 7 are keyed on the spindle 5 on each side of the corresponding extremity of the yoke 4 but independently of this latter. Similarly, a second spur pinion 9 with oblique teeth is keyed on the spindle 6 at the other extremity of the yoke 4. The two spindles 5 and 6 are mounted on two brackets 10 and 11 provided in a support 12 of revolution about an axis O—O′ located at right angles to the two axes X—X′ and Y—Y′ which have been defined earlier. Said support 12 is provided with an internal opening 13 which provides for the free passage of electrons of the beam of an electron diffractor (not shown in the drawings), the sample 1 being intended to be oriented with respect to the direction of said opening by means of the mechanism under consideration. The bottom portion of the support 12 has a flat annular flange 14 which is provided in its external surface with a set of teeth 15. In addition, two toothed wheels which are provided with teeth 16 and 17 in their external surfaces are freely mounted for rotational motion between the flange 14 and the upper portion of the support 12. The spur pinion 8 is associated with the set of teeth 17 by means of two countershaft pinions 42 and 44 carried by a shaft 43 which is mounted in the support 12. Similarly, the pinion 9 is coupled to the set of teeth 16 by means of two coupled pinions 45 and 47 carried by a shaft 46 which is parallel to the shaft 43 and also mounted in the support 12 (as shown in FIG. 3).

The three sets of teeth 15, 16 and 17 (shown in FIG. 2) are adapted to cooperate respectively with the teeth of the three pinions 18, 19 and 20 which are freely mounted on a shaft 21 which is parallel to the axis O—O′, said shaft 21 being in turn carried by a casing 22 which is secured to the support 12 by any suitable fastening means. Said three pinions 18, 19 and 20 are in turn adapted to cooperate with the extremities of three rods 23, 24 and 25 having screws with helical threads such as the screw 26, only the two screws which form part of the rods 23 and 25 being shown in the drawings of FIGS. 1 and 2 since the third screw is located on the other side of the assembly which is formed by the three pinions 18, 19 and 20. The ends of the three rods 23, 24 and 25 which are remote from the pinions just mentioned pass through the extremity 27 of a cylindrical sleeve 28 having an axis Z—Z′ which is parallel to the axis X—X′. There are mounted within the interior of said sleeve 28 and coaxially about the axis Z—Z′ three shafts 29, 30 and 31 fitted at their extremities with three toothed wheels 32, 33 and 34. Said wheels are adapted to cooperate with screws having helical threads such as the screw 35 which are formed at the corresponding extremities of the same rods 23, 24 and 25, namely at the end remote from the screws 26. As in the case of these latter, only two of the screws 35 appear in FIGS. 1 and 4, namely those corresponding to the rods 23 and 25. A control knob 36, 37 or 38 (as shown in FIG. 4) is associated with each shaft 29, 30 and 31. The knob 36 is rigidly fixed directly on the shaft 29 whilst the two other knobs 37 and 38 can be secured to or released from their shafts 30 or 31 by means of an engageable device comprising a ball 39 and a spring 40, the interlocking of a knob and the associated shaft being carried out by applying on said knob a force which is directed along the axis Z—Z′ so as to dislodge the ball 39 and compress the spring 40, thereby locking said knob against a thick disc 41 which is rigidly fixed to the corresponding shaft.

The control of orientation of the sample 1 about the three axes X—X′ and Y—Y′ and O—0′ or main orientation control can accordingly be described with reference to those portions of the mechanism which have been set forth in detail in the foregoing. This control operation is carried out in three separate movements each corresponding to one movement of rotation about any one of said axes.

1. Movement of rotation about the axis X—X′ without limitation.

This first movement corresponds directly to the rotation of the pinion 3 about its own axis, said pinion being rigidly fixed to the sample-holder block 2. This rotation is obtained by means of the bevel pinion 7 which rotates with the spindle 5 and is driven by the pinion 8. The rotational motion of said pinion 8 is obtained by means of the countershaft pinion 42 which is mounted on the shaft 43 and in turn driven by the pinion 44 which is disposed in meshing engagement with the set of teeth 17. The rotation of said set of teeth is obtained by means of the differential pinion 20 which is in turn driven by the end screw 26 of the rod 25. Said rod is driven by means of its other end screw 35 by the pinion 34 which is keyed on the shaft 31. Finally, the movement of rotation is communicated to said shaft by the knob 38 which is suitably engaged thereon.

2. Movement of adjustment of the incidence of the plane of the sample on the direction of the axis Y—Y'.

This adjustment of incidence is carried out by producing the pivotal movement of the yoke 4 about the axis Y—Y' through a limited angle of displacement, said axis being materialized by the spindles 5 and 6. This pivotal movement is obtained as a result of rotational movement of the pinion 9 which is fixed on the yoke, this movement of rotation being carried out by means of the countershaft pinion 45 which is mounted at the end of the shaft 46; a pinion 47 is mounted on the other end of said shaft and disposed in meshing engagement with the set of teeth 16. Said set of teeth is in turn adapted to cooperate with the differential pinion 19 and this latter is driven by the screw provided at the extremity of the rod 24. The movement of said rod is determined by means of the pinion 33 and the shaft 30 and this latter is controlled by the knob 37 which has previously been engaged. Stops which have not been shown in the drawings and are provided, for example, on the pinion 9 serve to limit the amplitude of resulting displacement of the yoke, the permitted angle being of the order of ±15° about the mean position.

3. Movement of rotation of the sample-holder block about the axis O—0' which is perpendicular to the axes X—X' and Y—Y'.

This movement is obtained by means of the set of teeth 15 which is provided at the lower portion of the support of revolution 12 and driven directly by the pinion 18, said pinion being in turn driven by the screw 26 provided at the extremity of the rod 23. The rod is actuated by its screw 35 which cooperates with the pinion 32 mounted at the end of the shaft 39 and this latter is directly driven in rotation about its own axis by means of the knob 36. An angle of displacement of ±80° is contemplated for this movement of the sample-holder block although this angle naturally does not constitute a mandatory limit.

The three movements thus obtained for the sample are wholly independent of each other, especially by virtue of the controlled engagement of at least two of the operating knobs, thereby preventing any faulty operation and especially any interaction of movements. It is in fact possible to regulate the incidence of the plane of the sample with respect to the electron beam by acting on the appropriate control so that said adjustment of incidence is not affected by a simultaneous or subsequent rotation of the sample-holder block about one of the two other axes. MOreover, the shaft 29 which carries the pinion 32 for producing rotation about the axis O—0' can advantageously be secured with respect to the sleeve 28 by means of a locking screw 48 (as shown in FIG. 4) so as to interlock said shaft and said sleeve.

Apart from the arrangements which are thus carried into effect, the apparatus under consideration is completed by ancillary means whereby three further degrees of freedom may be superimposed on the three degrees of freedom which have already been obtained.

4. MOvement of lateral displacement of the support sleeve.

With this objective, the support sleeve 28 is mounted within the interior of a casing 49 formed by a first portion 50 which is capable in particular of being secured against the wall of the observation chamber of the diffractor, leak-tightness being achieved by means of a seal 51 fitted within an annular flange 52, and by a second portion 53 which is coupled to the sleeve 28 and capable of undergoing with respect to the first portion a small movement of displacement along the direction of an axis W—W' located at right angles to the axis Z—Z' and parallel to the axis Y—Y'. To this end, said two portions 50 and 53 engage one inside the other within a transverse groove 60 having an orientation parallel to the axis W—W' and preferably having a dovetail profile. A bellows element 54 continuously ensures leak-tightness between these two portions in all respective positions of these latter. The relative displacement of one portion with respect to the other is obtained by means of a screw 55 fitted at one end with a control knob 56, said screw being adapted to cooperate with a nut 57 which is secured to the stationary portion 50 of the casing 49. Under these conditions, said screw communicates to a right-angled bracket 58 secured to a member 59 which is coupled to the sleeve 28 a lateral movement of displacement which causes the two portions 50 and 53 to slide with respect to each other within the dovetail groove 60. During this displacement, the portion 50 remains stationary whilst the portion 53 is accompanied in its movement by the support sleeve 28 and consequently by all the elements which are mounted within this latter and especially the support 12 of revolution of the sample-holder block 2.

5. MOvement of axial displacement of the support sleeve.

Another degree of freedom consists in permitting the displacement of the sleeve 28 within the interior of the casing 49 in the direction of the axis Z—Z' which materializes the common axis of the shafts 29, 30 and 31 and of the sleeve 28 which is parallel to the axis X—X'. To this end, the support sleeve 28 is associated with a capstan nut 61 fitted with operating handles 62 and mounted so as to cooperate with a threaded portion 63 provided in the outer surface of the sleeve. A ball bearing 64 permits the free rotation of the capstan nut whilst translational motion of this latter is prevented by a ring 65 which is mounted on an extension of the portion 53. The rotational motion of the capstan nut is therefore transformed into a translational motion along the axis Z—Z', leak-tightness being maintained by means of seals 67 between the outer surface of the sleeve and a flange 68 forming part of the portion 53 of the casing 49.

6. Movement of rotation of the support sleeve about the axis Z—Z'.

This rotation of the sleeve 28 is obtained by means of a crank-plate 69 whose axis 70 (as shown in FIG. 5) coincides with the axis of a screw 71, said screw being disposed in mesh with a set of teeth formed in the external surface of the sleeve 28. Operation of the crank-plate 69 by means of the handle 72 thus causes the rotation of the sleeve 28 about its own axis and the rotation of all the elements supported by said sleeve. It should be noted that the orientation of the threads of the screw 71 is necessarily determined so that these latter are parallel to the direction of the axis Z—Z' in order that the displacement produced as a result of operation of the capstan nut 61 can be carried out in the direction of said axis.

The sample-orientation mechanism as thus constructed makes it possible to place the sample in the beam of an electron diffractor in any position which may be necessary for the purposes of analysis. In particular, the device according to the invention makes it possible to employ as samples both thin films in which the electron beam is produced in a direction substantially at right angles to the planes of such films and passes through these latter and solid samples whose surface is brought practically parallel to the beam. The accuracy of the device can be of a very high order which is limited solely by the precision obtainable at the time of machining of the pinions and teeth employed. Moreover, the pinions are preferably mounted with a system for taking up play which ensures high accuracy of adjustment of the different movements.

Finally, further important advantages of the apparatus in accordance with the invention result from the following arrangements as employed in combination while retaining the freedom of orientation of the six movements as described in the foregoing. Thus, the sample can be placed within a high-vacuum enclosure, leak-tightness of the sample-holder block which is fitted with its gear-drive mechanism being ensured in particular by means of the seals **51** and **67**. In addition, the temperature of the sample can be brought to between −100° C. and +1,000° C. by means of a heating or cooling system (not illustrated) which is located within the enclosure and capable of operating independently without any need of disassembly or reconnection to the surrounding air.

It will be apparent that the invention is not limited in any sense to the example of construction which has been more especially described with reference to the drawings but extends on the contrary to all alternative forms.

We claim:

**1**. A variable-orientation mechanism with six degrees of freedom for positioning samples comprising a sample-holder block mounted to rotate about a first axis carried by a yoke, said yoke being pivoted about a second axis located at right angles to the first axis, said yoke being in turn carried by a support of revolution rotating about a third axis at right angles to the axes aforesaid, a set of pinions mounted on said support controlling independently the movements of the sample-holder block about the three axes, ring gears on said support, gearing means between said ring gears and said pinions for driving said pinions, a set of three rods, helical-thread screws on the ends of said rods, gearing means between said ring gears and said screws for transmitting movement to said ring gears and to the differential pinions, three toothed wheels rotating said rods and rigidly fixed to three concentric shafts, a support sleeve carrying said shafts, said shafts being driven in rotation by engageable operating knobs, a two-part cylindrical casing mounted coaxially with said sleeve and means for displacing said sleeve with respect to said casing independently in the direction of the common axis thereof, in a direction at right angles to said axis and in rotation about said axis.

**2**. A mechanism in accordance with claim **1**, said two parts of said cylindrical casing being interengaged by a dovetail groove means formed in a direction at right angles to the direction of the axis of said support sleeve, said means for displacing said sleeve with respect to said casing including a screw and nut means for controlling the relative displacement thereof.

**3**. A mechanism in accordance with claim **1**, said means for displacing said sleeve with respect to said casing including a threaded portion coacting with a capstan nut secured against translational motion with respect to said cylindrical casing and rotation of said nut causing displacement of said sleeve in the direction of its axis.

**4**. A mechanism in accordance with claim **1**, said means for displacing said sleeve with respect to said casing including a crank-plate means for actuating a helical-thread screw coacting with a set of teeth formed in the outer surface of said support sleeve, the threads of the screw being parallel to the direction of the axis of said sleeve.