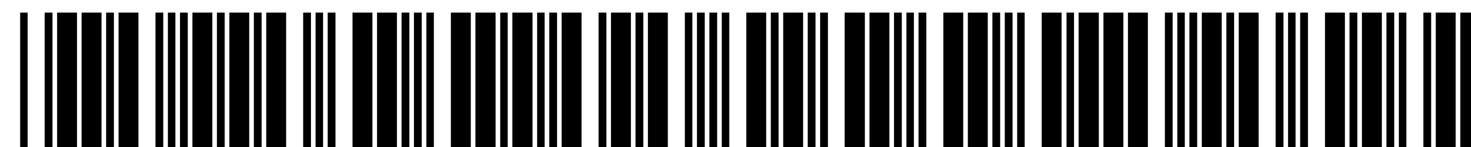

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(54) **POSITIONING DEVICE HAVING TWO OBJECT HOLDERS**

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G03B 27/42 (2006.01)
G03B 11/00 (2006.01)

(52) **U.S. Cl.** **355/53**; 356/401
(58) **Field of Classification Search** 355/53, 355/55, 75, 72; 356/399, 400, 401; 396/624, 396/611; 310/12; 318/687
See application file for complete search history.

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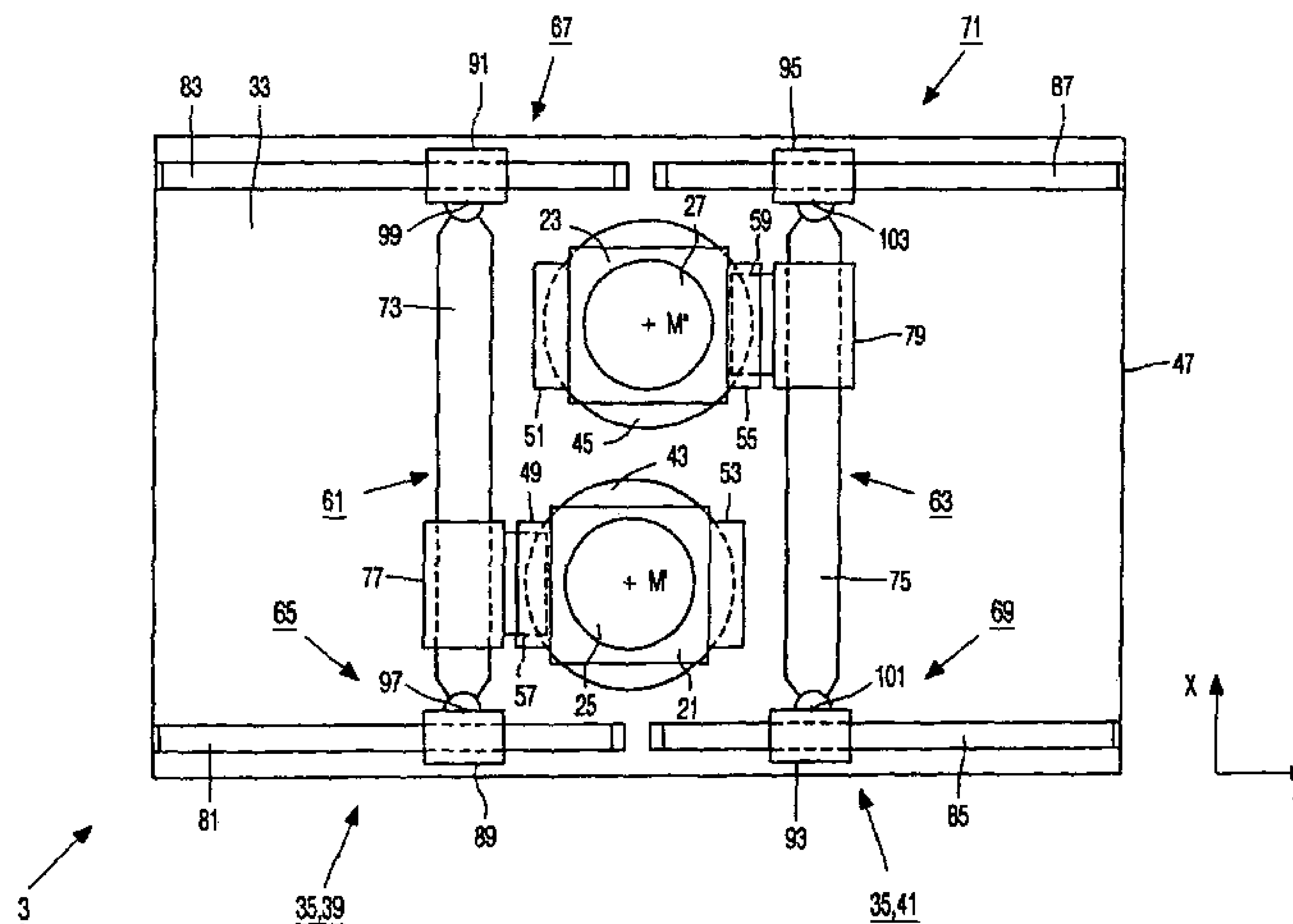
(57) **ABSTRACT**

A positioning device has first and second object holders that are guided over a guiding surface extending parallel to an X-direction and parallel to a Y-direction perpendicular to the X-direction and which are displaceable over the guiding surface from a first position into a second position by means of a displacement system. The displacement system includes a first displacement unit and a second displacement unit to which the object holders can be alternately coupled. The first displacement unit is suitable for carrying out a first series of positioning steps of the first object holder in the first position and for displacing the first object holder from the first position into an intermediate position between the first and second positions. The second displacement unit is suitable for carrying out a second series of positioning steps of the second object holder in the second position, simultaneously with and independently of the first displacement unit, and for displacing the second object holder from the second position into the intermediate position. In the intermediate position, the object holders are exchanged, after which the first series of positioning steps can be carried out by the first displacement unit with the second object holder in the first position and the second series of positioning steps can be carried out by the second displacement unit with the first object holder in the second position. The positioning device is suitable for use in a lithographic device to carry out an exposure process with a first semiconductor substrate in an exposure position and, simultaneously therewith and independently thereof, a characterization process with a second semiconductor substrate in a characterization position.

15 Claims, 4 Drawing Sheets



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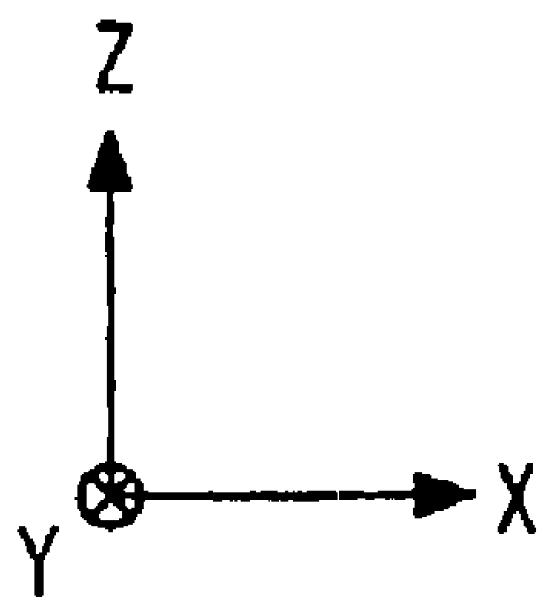
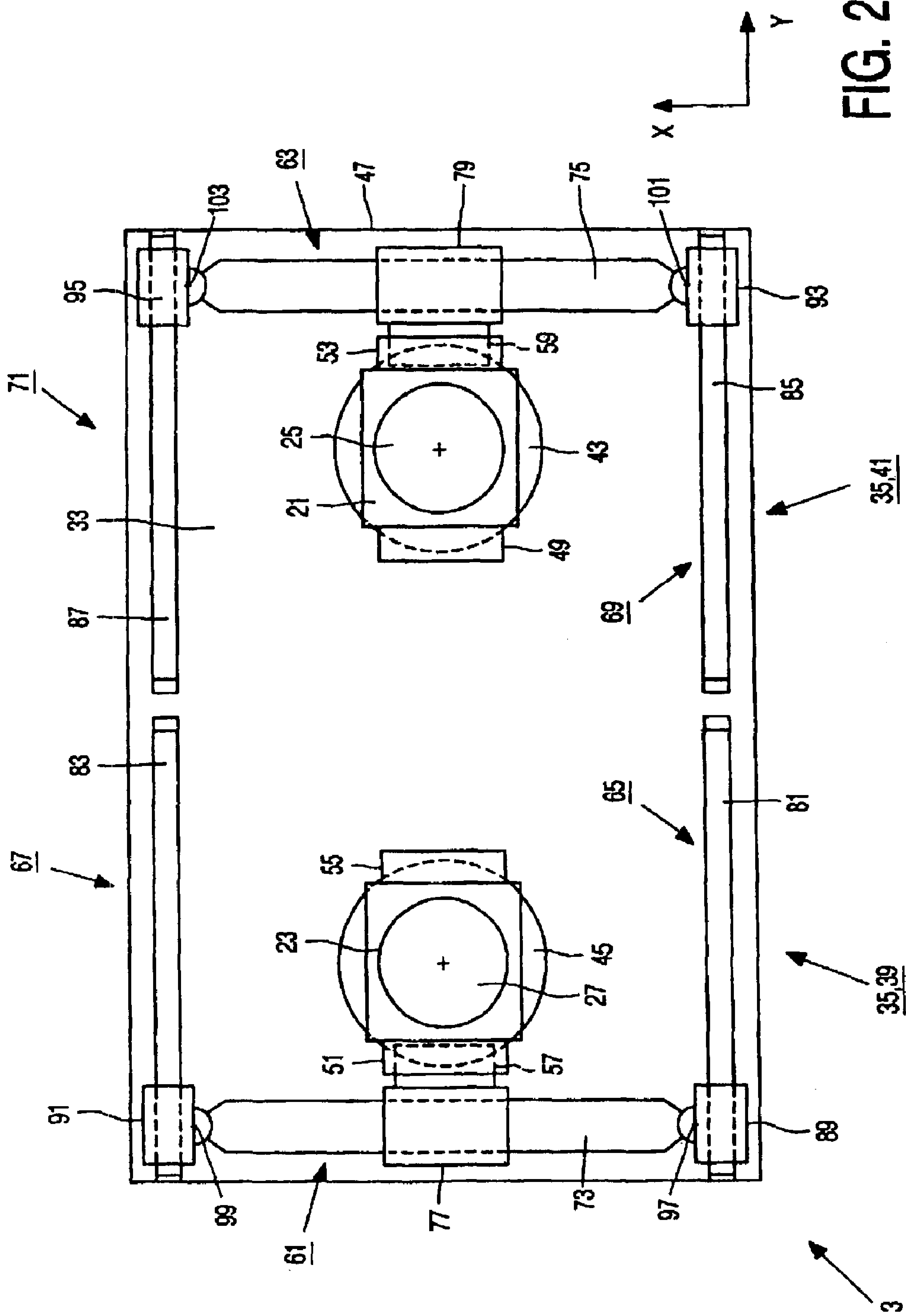


FIG. 1


Y
X
FIG. 2
63
47
79
75
101
103
95
93
53
59
71
85
25
43
21
33
35,41
49
69
87
83
81
65
67
55
23
45
27
35,39
51
57
91
89
99
77
73
97
61
31

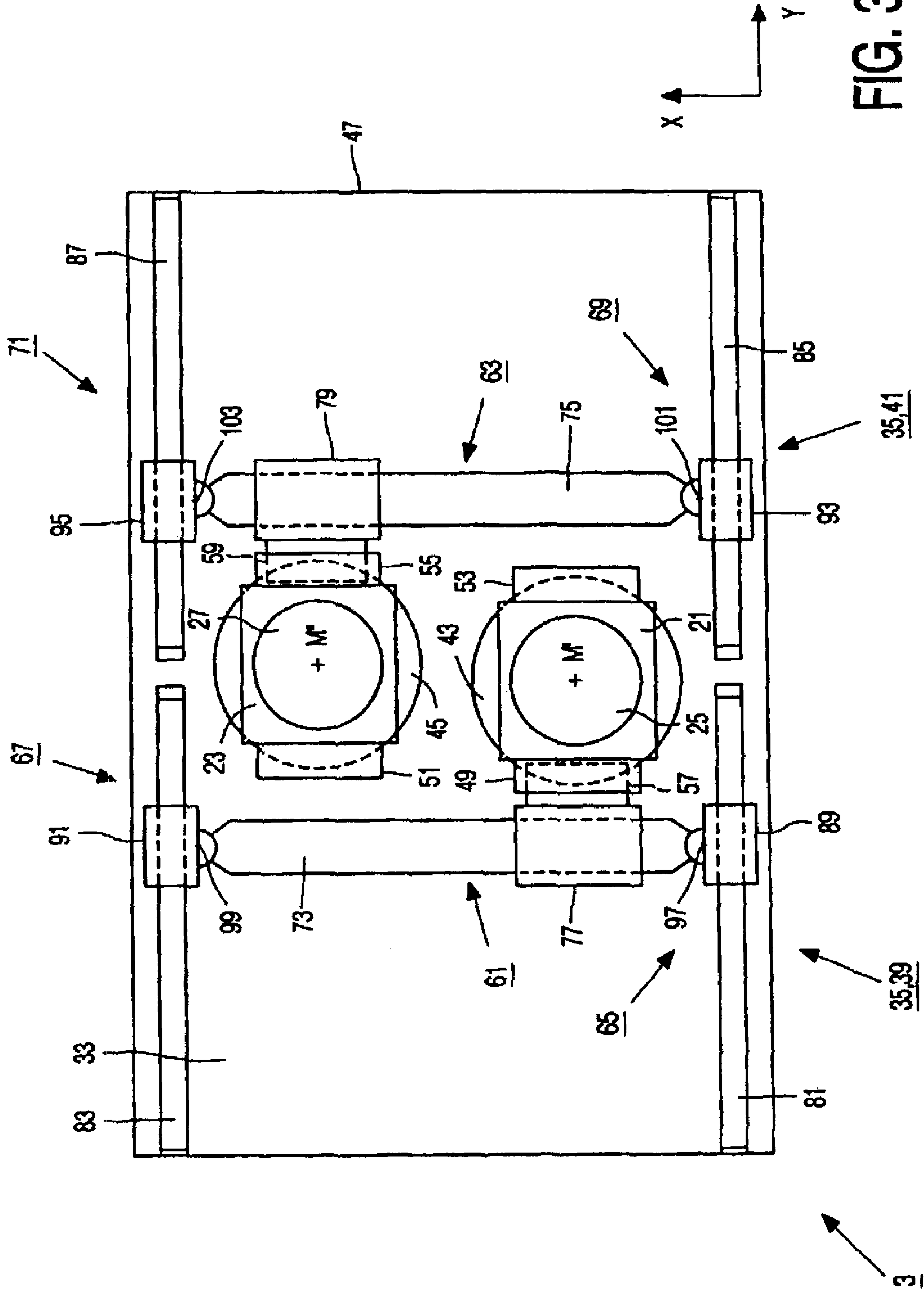


FIG. 3
X
Y
3
33
35,39
35,41
47
61
63
65
67
69
71
+ M'
+ M"
21
23
25
27
43
45
49
51
53
55
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73
75
77
79
81
83
85
87
89
91
93
95
97
99
101
103

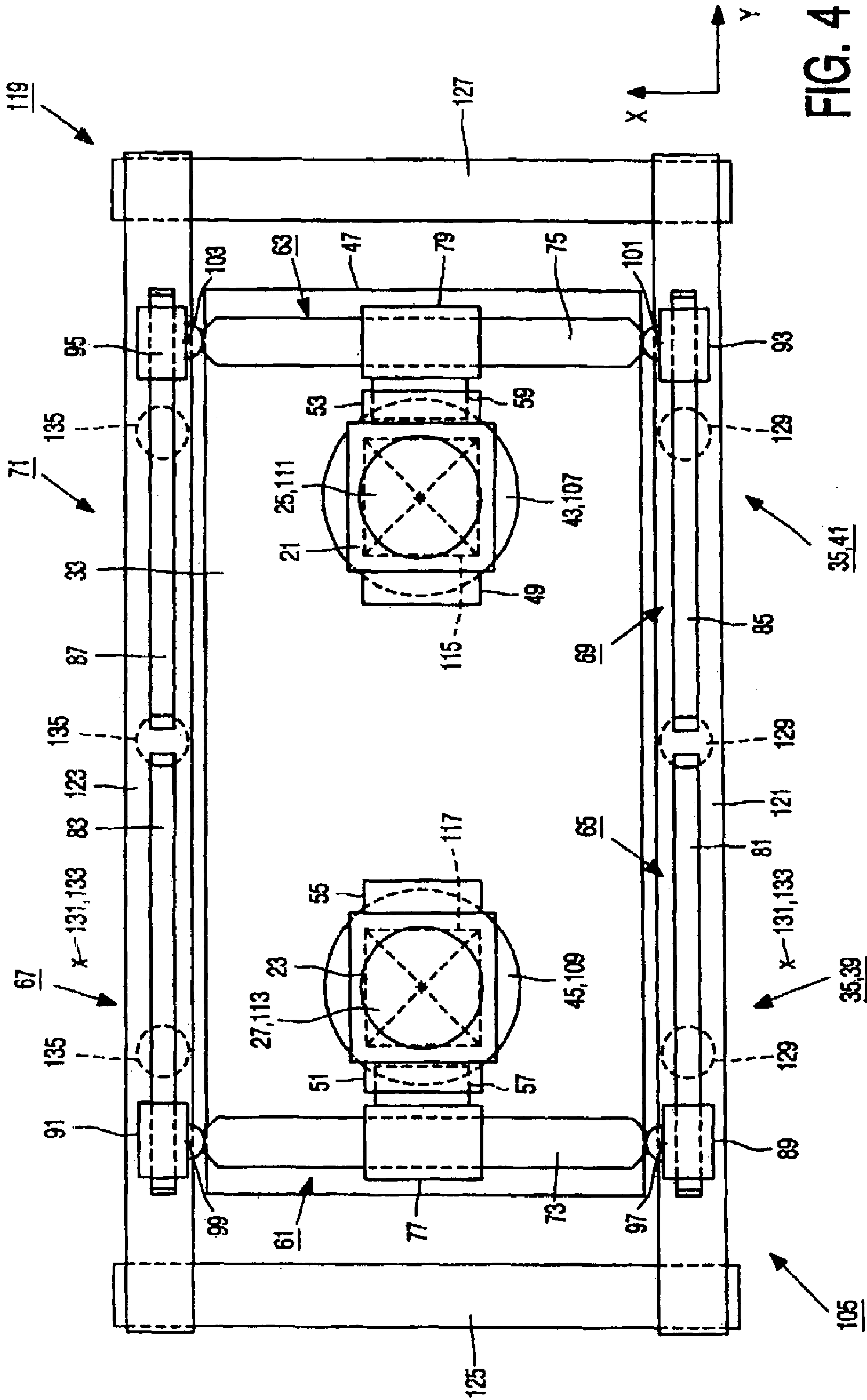
FIG. 4
X
Y
119
127
47
63
79
75
101
103
95
93
53
59
135
129
71
25,111
21
43,107
35,41
33
49
115
69
85
87
135
129
123
121
83
81
65
117
55
131,133
131,133
67
23
27,113
45,109
35,39
135
129
51
57
91
89
99
97
61
77
73
105
125

POSITIONING DEVICE HAVING TWO OBJECT HOLDERS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

The invention relates to a positioning device having a guiding surface extending parallel to an X-direction and parallel to a Y-direction, a first object holder and a second object holder which are each guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position, and a displacement system for displacing the first object holder and the second object holder over the guiding surface.

The invention further relates to a lithographic device provided with a radiation source, a mask holder, a focusing unit having a main axis, a characterization unit, and a positioning device, said positioning device comprising a guiding surface extending parallel to an X-direction, which is perpendicular to the main axis, and parallel to a Y-direction, which is perpendicular to the X-direction and the main axis, a first substrate holder and a second substrate holder which are each guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position which is present near the focusing unit, and a displacement system for displacing the first substrate holder and the second substrate holder over the guiding surface.

A positioning device and a lithographic device of the kinds mentioned in the opening paragraphs are known from EP-A-0 687 957. The known lithographic device is used for the exposure of semiconductor substrates in the manufacturing process of integrated semiconductor circuits and operates according to the so-called step-and-repeat process. The known positioning device is used in the known lithographic device for displacing semiconductor substrates relative to the focusing unit and relative to the characterization unit. The first position of the known positioning device is a load and unload position in which a semiconductor substrate can be loaded on or unloaded from the first or the second object holder. The second position of the positioning device is an exposure position in which a semiconductor substrate present on the first or the second object holder can be exposed via the focusing unit. The first and the second object holder are displaceable from the first position to the second position and vice versa by the displacement system of the positioning device which is not described in detail in EP-A-0 687 957. When the first object holder is in the second position and the semiconductor substrate present thereon is being exposed, the second object holder is in the first position and a next semiconductor substrate is loaded thereon at first. Then the second object holder is displaced from the first position to a characterization position in which the semiconductor substrate present on the second object holder is characterized by the characterization unit. When the second object holder is in the characterization position, the first object holder and the second object holder are displaced lockstep-wise. In this manner the exposure of the semiconductor substrate present on the first object holder and the characterization of the semiconductor substrate present on the second object holder are carried out simultaneously, so that a high throughput of the step-and-repeat apparatus is obtained.

A disadvantage of the known positioning device and the known lithographic device is that the characterization of the semiconductor substrate present on the second object holder and the exposure of the semiconductor substrate present on the first object holder cannot be carried out independently from each other as a result of said lockstep-wise displacements of the first and the second object holder. As a result, the exposure of the semiconductor substrate present on the first object holder cannot be started until the second object holder has reached the characterization position.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a positioning device of the kind mentioned in the opening paragraph in which a first process involving a first series of positioning steps of the first object holder can be carried out simultaneously with and independently from a second process involving a second series of positioning steps of the second object holder, and in which also the first process can be carried out with the second object holder and, simultaneously and independently, the second process can be carried out with the first object holder.

It is a further object of the present invention to provide a lithographic device of the kind mentioned in the second paragraph in which a characterization process involving a first series of positioning steps of the first substrate holder can be carried out simultaneously with and independently from an exposure process involving a second series of positioning steps of the second substrate holder, and in which also the characterization process can be carried out with the second substrate holder and, simultaneously and independently, the exposure process can be carried out with the first substrate holder.

The positioning device according to the invention is for this purpose characterized in that the displacement system comprises a first displacement unit and a second displacement unit to which the first object holder and the second object holder can be coupled alternately, the first displacement unit being suitable for displacing the object holders from the first position into an intermediate position between the first position and the second position, and the second displacement unit being suitable for displacing the object holders from the intermediate position into the second position. As a result of the use of said first and second displacement units, a first process involving a first series of positioning steps of the first object holder can be carried out in the first position by means of the first displacement unit, and a second process involving a second series of positioning steps of the second object holder can be carried out in the second position by means of the second displacement unit simultaneously with and independently from the first process. When the first process and the second process have been completed, the first object holder is displaced by the first displacement unit from the first position into the intermediate position and the second object holder is displaced by the second displacement unit from the second position into the intermediate position. In the intermediate position, the first object holder is uncoupled from the first displacement unit and is coupled to the second displacement unit, while the second object holder is uncoupled from the second displacement unit and is coupled to the first displacement unit. Subsequently, the first object holder is displaced by the second displacement unit from the intermediate position to the second position and the second object holder is displaced by the first displacement unit from the intermediate position to the first position. Then the first process can be carried out with the second object holder in the first position and,

simultaneously and independently, the second process can be carried out with the first object holder in the second position. Furthermore, as a result of the use of said two displacement units, a distance over which each individual displacement unit has to displace the object holders is reduced, so that the required dimensions of the displacement units are reduced. It is in addition prevented that the displaceable parts of the first displacement unit and the displaceable parts of the second displacement unit must be constructed so as to be capable of passing one another, which allows a comparatively simple construction of the displacement units.

The lithographic device according to the invention is for this purpose characterized in that the positioning device of the lithographic device is a positioning device according to the invention, wherein each of the object holders of the positioning device is a substrate holder of the lithographic device, and wherein the first position of the object holders is a characterization position which is present near the characterization unit. As a result of the use of the positioning device according to the invention in the lithographic device according to the invention, a characterization process involving a first series of positioning steps of the first substrate holder can be carried out in the first position by means of the first displacement unit of the positioning device, and an exposure process involving a second series of positioning steps of the second substrate holder can be carried out in the second position by means of the second displacement unit of the positioning device simultaneously with and independently from the first process. The first process can also be carried out with the second substrate holder in the first position and, simultaneously and independently, the second process can be carried out with the first object holder in the second position.

A particular embodiment of a positioning device according to the invention is characterized in that the displacement units each comprise an X-motor having a first part extending parallel to the X-direction and a second part which is displaceable along the first part of the X-motor and can be coupled alternately to the first object holder and to the second object holder, and two Y-motors each having a first part extending parallel to the Y-direction and a second part which is displaceable along the first part of the relevant Y-motor, the first part of the X-motor of each displacement unit being connected to the second parts of the two Y-motors of the relevant displacement unit. Since the first part of the X-motor of each displacement unit is connected to the second parts of the two Y-motors of the relevant displacement unit, a comparatively stiff and stable support of the X-motor by the two Y-motors is obtained, which benefits the positioning accuracy of the displacement unit. Since the first displacement unit has a limited displacing range from the first position to the intermediate position and the second displacement unit has a limited displacing range from the intermediate position to the second position, the four Y-motors of the two displacement units can be arranged in two lines, which leads to a compact and simple construction of the positioning device.

A further embodiment of a positioning device according to the invention is characterized in that the first parts of the Y-motors of the two displacement units are connected to a common balancing unit which is guided relative to a base of the positioning device so as to be displaceable parallel to the X-direction and parallel to the Y-direction and to be rotatable about an axis of rotation extending perpendicularly to the X-direction and the Y-direction. Since the first parts of the Y-motors of the displacement units are connected to said common balancing unit, reaction forces of the X-motors and the Y-motors of the displacement units are transmitted via the first parts of the Y-motors to the balancing unit and are converted into displacements of the balancing unit parallel to the X-direction and parallel to the Y-direction and rotations of the balancing unit about said axis of rotation relative to the base. In this manner, a transmission of the reaction forces to the base, the guiding surface, and the object holders is prevented as much as possible, so that the positioning accuracy of the positioning device is further improved.

A yet further embodiment of a positioning device according to the invention is characterized in that the object holders each comprise a basic part which is guided over the guiding surface and can be coupled to the displacement units, and an object table which is displaceable relative to the basic part by means of an actuator unit of the relevant object holder. In this yet further embodiment of the positioning device, the object tables of the object holders are displaceable by the displacement units over comparatively large distances and with comparatively low accuracies, while the object tables are displaceable by said actuator units over comparatively small distances and with comparatively high accuracies. In this manner, the displacement units can be of a relatively simple, conventional type, while the dimensions of the accurate actuator units can be limited as much as possible.

A particular embodiment of a positioning device according to the invention is characterized in that the object table of each of the object holders is displaceable relative to the basic part parallel to the X-direction, parallel to the Y-direction, and parallel to a Z-direction extending perpendicularly to the X-direction and the Y-direction, and is pivotable relative to the basic part about a first pivot axis extending parallel to the X-direction, a second pivot axis extending parallel to the Y-direction, and a third pivot axis extending parallel to the Z-direction. In this manner, a high degree of adjustability of the object tables relative to the basic parts is obtained.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be explained in more detail below with reference to the drawing, in which

FIG. **1** diagrammatically shows a lithographic device according to the invention,

FIG. **2** is a diagrammatic plan view of a first embodiment of a positioning device according to the invention suitable for use in the lithographic device of FIG. **1**,

FIG. **3** shows the positioning device of FIG. **2**, two substrate holders of the positioning device being in an intermediate position, and

FIG. **4** is a diagrammatic plan view of a second embodiment of a positioning device according to the invention suitable for use in the lithographic device of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The lithographic device according to the invention shown diagrammatically in FIG. **1** is used for the exposure of semiconductor substrates in the manufacturing process of integrated semiconductor circuits and comprises a frame **1** which supports in that order, as seen parallel to a vertical Z-direction, a positioning device **3** according to the invention, a focusing unit **5**, a mask holder **7**, and a radiation source **9**. The lithographic device is an optical lithographic device whose radiation source **9** comprises a light source **11**. The mask holder **7** comprises a support surface **13** which

extends perpendicularly to the Z-direction and on which a mask **15** can be placed comprising a pattern or a sub-pattern of an integrated semiconductor circuit. The focusing unit **5** is an imaging or projection system and comprises an optical lens system **17** having a main optical axis **19** extending parallel to the Z-direction and an optical reduction factor of, for example, **4** or **5**. The positioning device **3** comprises a first substrate holder **21** and a second substrate holder **23** which is identical to the first substrate holder **21**. The substrate holders **21**, **23** each comprise a support surface **25**, **27** which extends perpendicularly to the Z-direction. In the situation shown in FIG. **1**, a first semiconductor substrate **29** is present on the support surface **25** of the first substrate holder **21** and a second semiconductor substrate **31** is present on the support surface **27** of the second substrate holder **23**. The positioning device **3** further comprises a guiding surface **33** extending parallel to a horizontal X-direction which is perpendicular to the Z-direction and parallel to a horizontal Y-direction which is perpendicular to the X-direction and the Z-direction. The substrate holders **21**, **23** are each guided over the guiding surface **33** and are each displaceable over the guiding surface **33** parallel to the X-direction and parallel to the Y-direction by means of a displacement system **35** of the positioning device **3**.

In the situation shown in FIG. **1**, the first substrate holder **21** with the first semiconductor substrate **29** is in a second position of the positioning device **3** which corresponds to an exposure position of the lithographic device which is present near the focusing unit **5**. In this position, a light beam originating from the light source **11** is guided through the mask **15** and is focused on the first semiconductor substrate **29** by means of the focusing unit **5**, so that the pattern present on the mask **15** is imaged on a reduced scale on the first semiconductor substrate **29**. The first semiconductor substrate **29** comprises a large number of individual fields on which identical semiconductor circuits are to be imaged. The fields of the first semiconductor substrate **29** are consecutively exposed through the mask **15** for this purpose. The exposure process used in the lithographic device of FIG. **1** is a so called step-and-repeat exposure process according to which the first semiconductor substrate **29** and the mask **15** are in fixed positions relative to the focusing unit **5** during the exposure of an individual field of the first semiconductor substrate **29**, and according to which a next field of the first semiconductor substrate **29** is brought into position relative to the focusing unit **5** after the exposure of a previously exposed field in that the first substrate holder **21** is displaced parallel to the X-direction and/or parallel to the Y-direction by the displacement system **35** of the positioning device **3**. This process is repeated a number of times, with a different mask each time, so that complicated integrated semiconductor circuits with a layered structure can be manufactured.

In the situation shown in FIG. **1**, the second substrate holder **23** with the second semiconductor substrate **31** is in a first position of the positioning device **3** which corresponds to a characterization position of the lithographic device. In the situation shown, a previous semiconductor substrate, which was fully exposed in the exposure position via the mask **15**, was unloaded from the second substrate holder **23** and was transported to a stack of semiconductor substrates under manufacture not shown in the figure. The second semiconductor substrate **31** shown in FIG. **1** is a next semiconductor substrate which has just been taken from said stack of semiconductor substrates and loaded on the second substrate holder **23** and which has to be exposed via the mask **15** after the first semiconductor substrate **29**. In the characterization position, the second semiconductor substrate **31** is characterized by a characterization unit **37** of the lithographic device which is also supported by the frame **1**. When the second semiconductor substrate **31** has been fully characterized and the first semiconductor substrate **29** has been fully exposed, the second substrate holder **23** with the second semiconductor substrate **31** is displaced by the displacement system **35** from the characterization position into the exposure position and the first substrate holder **21** with the first semiconductor substrate **29** is displaced by the displacement system **35** from the exposure position into the characterization position. The characterization unit **37** comprises, for example, a measuring system which is used for measuring the positions of the individual fields of the second semiconductor substrate **31** relative to the second substrate holder **23**. Since these positions are already measured in the characterization position, the individual fields of the second semiconductor substrate **31** can subsequently be positioned relative to the focusing unit **5** in the exposure position by measuring the position of the second substrate holder **23** relative to the focusing unit **5**. In this manner, the time required to position the individual fields of the successive semiconductor substrates relative to the focusing unit **5** in the exposure position is limited considerably, so that the throughput of the lithographic device is considerably improved. Since the position of each individual field of the second semiconductor substrate **31** has to be measured in the characterization position, a step wise displacement of the second substrate holder **23** with the second semiconductor substrate **31** is carried out by the displacement system **35** of the positioning device **3** in the characterization position. As a result of the use of the two separate identical substrate holders **21** and **23**, the exposure process of a semiconductor substrate in the exposure position can be carried out simultaneously with the unload process of a previous semiconductor substrate and the load and characterization processes of a next semiconductor substrate in the characterization position, so that the throughput of the lithographic device is further improved.

As shown in FIG. **2**, the displacement system **35** of the positioning device **3** comprises a first displacement unit **39** and a second displacement unit **41**. The substrate holders **21**, **23** each comprise an aerostatically supported foot **43**, **45** provided with a static gas bearing by means of which the relevant substrate holder **21**, **23** is guided over the guiding surface **33**. The guiding surface **33** constitutes an upper surface of a granite block **47** which is fastened to the frame **1** of the lithographic device. Furthermore, the substrate holders **21**, **23** each comprise a first coupling member **49**, **51** and a second coupling member **53**, **55** by means of which the substrate holders **21**, **23** can be coupled alternately to a coupling member **57** of the first displacement unit **39** and to a coupling member **59** of the second displacement unit **41**, respectively. In the situation shown in FIG. **2**, the first substrate holder **21** is coupled to the coupling member **59** of the second displacement unit **41** and the second substrate holder **23** is coupled to the coupling member **57** of the first displacement unit **39**. Alternatively, the first substrate holder **21** can be coupled to the coupling member **57** of the first displacement unit **39** and the second substrate holder **23** can be coupled to the coupling member **59** of the second displacement unit **41**. The coupling members **49**, **51**, **53**, **55**, **57**, **59** may be of a type which is known and usual per se, such as, for example, a mechanical or an electromechanical coupling member.

As FIG. **2** shows, the first displacement unit **39** and the second displacement unit **41** each comprise a linear X-motor **61**, **63** and two linear Y-motors **65**, **67**, **69**, **71** of a conven-

tional type which is known and usual per se. The X-motors **61**, **63** each comprise a first part **73**, **75** extending parallel to the X-direction and a second part **77**, **79** which is displaceable along the first part **73**, **75** of the relevant X-motor **61**, **63** and comprises the coupling member **57**, **59** of the relevant X-motor **61**, **63**. The Y-motors **65**, **67**, **69**, **71** each comprise a first part **81**, **83**, **85**, **87** extending parallel to the Y-direction and a second part **89**, **91**, **93**, **95** which is displaceable along the first part **81**, **83**, **85**, **87** of the relevant Y-motor **65**, **67**, **69**, **71**. The X-motor **61** and the two Y-motors **65**, **67** of the first displacement unit **39** are mutually arranged in a H-configuration, a first end **97** and a second end **99** of the first part **73** of the X-motor **61** being coupled to the second part **89** of the Y-motor **65** and to the second part **91** of the Y-motor **67**, respectively. Likewise, the X-motor **63** and the two Y-motors **69**, **71** of the second displacement unit **41** are mutually arranged in a H-configuration, a first end **101** and a second end **103** of the first part **75** of the X-motor **63** being coupled to the second part **93** of the Y-motor **69** and to the second part **95** of the Y-motor **71**, respectively.

In the situation shown in FIG. **2**, the second substrate holder **23** is in the first position or characterization position and a characterization process involving a first series of positioning steps of the second substrate holder **23** is carried out by means of the first displacement unit **39**. Simultaneously, the first substrate holder **21** is in the second position or exposure position and an exposure process involving a second series of positioning steps of the first substrate holder **21** is carried out by means of the second displacement unit **41**. Thus, as a result of the use of the first displacement unit **39** and the second displacement unit **41**, the characterization process can be carried out not only simultaneously with but also independently from the exposure process. When the exposure process with the first substrate holder **21** and the characterization process with the second substrate holder **23** have been completed, the first substrate holder **21** is displaced by means of the second displacement unit **41** from the exposure position into an intermediate position M' between the exposure position and the characterization position as shown in FIG. **3**, and the second substrate holder **23** is displaced by means of the first displacement unit **39** from the characterization position into an intermediate position M" between the exposure position and the characterization position. In said intermediate positions M' and M", the second coupling member **53** of the first substrate holder **21** is uncoupled from the coupling member **59** of the second displacement unit **41** and the first coupling member **51** of the second substrate holder **23** is uncoupled from the coupling member **57** of the first displacement unit **39**. Subsequently, the coupling member **57** of the first displacement unit **39** is coupled to the first coupling member **49** of the first substrate holder **21** and the coupling member **59** of the second displacement unit **41** is coupled to the second coupling member **55** of the second substrate holder **23**, as shown in FIG. **3**. Then, the first substrate holder **21** is displaced by the first displacement unit **39** from the intermediate position M' into the characterization position where the substrate present on the first substrate holder **21** is unloaded and a next substrate is loaded and characterized. Simultaneously therewith and independently therefrom, the second substrate holder **23** is displaced by the second displacement unit **41** from the intermediate position M" into the exposure position where the substrate present on the second substrate holder **23** is exposed. Since the first displacement unit **39** is suitable for displacing both substrate holders **21** and **23** from the first position or characterization position into the intermediate positions M' and M" and the second displacement unit **41** is suitable for displacing both substrate holders **21** and **23** from the intermediate positions M' and M" into the exposure position, a distance over which each displacement unit **39**, **41** must be able to displace the substrate holders **21** and **23** is reduced, so that the required dimensions of the displacement units **39**, **41** are reduced. As FIG. **2** shows, particularly the dimensions of the Y-motors **65**, **67**, **69**, **71** of the displacement units **39**, **41** are considerably reduced as seen parallel to the Y-direction. Furthermore, the use of the two displacement units **39**, **41** prevents that the displaceable parts of the displacement system **35**, in particular the X-motors **61** and **63**, must be constructed so as to be capable of passing one another, as a result of which a comparatively simple construction of the displacement system **35** is achieved. The arrangement of the two X-motors **61**, **63** and the four Y-motors **65**, **67**, **69**, **71** in two H-configurations leads to a comparatively stiff and stable support of X-motors **61**, **63** by the relevant Y-motors **65**, **67**, **69**, **71**, which benefits the positioning accuracy of the displacement units **39**, **41**. The limited displacing range of the displacement units **39**, **41** as seen parallel to the Y-direction enables the mutual arrangement of the four Y-motors **65**, **67**, **69**, **71** in two lines of two Y-motors **65**, **69** and **67**, **71** each, which leads to a compact and simple construction of the positioning device **3**.

FIG. **4** shows a second embodiment of a positioning device **105** according to the invention suitable for use in the lithographic device according to the invention. Corresponding parts of the first embodiment of the positioning device **3** and the second embodiment of the positioning device **105** are indicated by means of corresponding reference numerals in FIGS. **2**, **3**, and **4**. Hereafter, only the main differences between the positioning devices **3** and **105** will be discussed.

The substrate holders **21** and **23** of the positioning device **105** each comprise a basic part **107**, **109** which comprises the aerostatically supported foot **43**, **45**, the first coupling member **49**, **51**, and the second coupling member **53**, **55** of the relevant substrate holder **21**, **23**. Furthermore, the substrate holders **21**, **23** of the positioning device **105** each comprise a substrate table **111**, **113** which comprises the support surface **25**, **27** of the relevant substrate holder **21**, **23**. The substrate holders **21**, **23** each comprise ah actuator unit **115**, **117** which is indicated diagrammatically only in FIG. **4** and by means of which the substrate table **111**, **113** of the relevant substrate holder **21**, **23** is displaceable relative to the basic part **107**, **109** of the relevant substrate holder **21**, **23**. In the second embodiment of the positioning device **105** according to the invention, the actuator units **115**, **117** each comprise a system of contactless Lorentz-force motors which are known and usual per se and by means of which the substrate table **111**, **113** of the relevant substrate holder **21**, **23** is displaceable relative to the basic part **107**, **109** of the relevant substrate holder **21**, **23** with comparatively high accuracies and over comparatively small distances in directions parallel to the X-direction, parallel to the Y-direction, and parallel to the Z-direction, and by means of which the substrate table **111**, **113** of the relevant substrate holder **21**, **23** is pivotable relative to the basic part **107**, **109** of the relevant substrate holder **21**, **23** with comparatively high accuracies and over comparatively small angles about a first pivot axis extending parallel to the X-direction, a second pivot axis extending parallel to the Y-direction, and a third pivot axis extending parallel to the Z-direction. In this manner, the displacement units **39**, **41** each constitute a so called coarse-fine displacement unit wherein the substrate holders **21**, **23** with the substrate tables **111**, **113** are dis-

placeable over comparatively large distances and with comparatively low accuracies by means of the X-motors **61**, **63** and the Y-motors **65**, **67**, **69**, **71** of the displacement units **39**, **41**, and wherein the substrate tables **111**, **113** are displaceable and pivotable with comparatively high accuracies and over comparatively low distances and small angles relative to the basic parts **107**, **109** of the substrate holders **21**, **23** by means of the actuator units **115**, **117** of the displacement units **39**, **41**. In this manner, the X-motors **61**, **63** and the Y-motors **65**, **67**, **69**, **71** can be of a relatively simple, conventional, and low-cost type, while the required dimensions and therefore the costs of the accurate and advanced actuator units **115**, **117** can be limited as much as possible. The use of the actuator units **115**, **117** as described further provides a high degree of adjustability of the substrate tables **111**, **113** relative to the focusing unit **5** and relative to the characterization unit **37** of the lithographic device.

As FIG. **4** further shows, the first parts **81**, **83**, **85**, **87** of the Y-motors **65**, **67**, **69**, **71** of the displacement units **39**, **41** of the positioning device **105** are fastened to a balancing unit **119** which is common for the two displacement units **39**, **41**. The balancing unit **119** comprises a first beam **121** which extends substantially parallel to the Y-direction and to which the first part **81** of the Y-motor **65** of the first displacement unit **39** and the first part **85** of the Y-motor **69** of the second displacement unit **41** are fastened, and a second beam **123** which also extends substantially parallel to the Y-direction and to which the first part **83** of the Y-motor **67** of the first displacement unit **39** and the first part **87** of the Y-motor **71** of the second displacement unit **41** are fastened. The first beam **121** and the second beam **123** are interconnected by means of a first cross-beam **125** and a second cross-beam **127**, the beams **121** and **123** and the cross-beams **125** and **127** being arranged in a rectangular configuration which surrounds the granite block **47** carrying the guiding surface **33**. As FIG. **4** diagrammatically shows, the first beam **121** of the balancing unit **119** is guided by means of static gas bearings **129** over a further guiding surface **131** which is provided on a base **133** of the positioning device **105** and extends parallel to the X-direction and parallel to the Y-direction, and the second beam **123** of the balancing unit **119** is guided by means of static gas bearings **135** over said further guiding surface **131**. Thus, the balancing unit **119** is displaceable in direction parallel to the X-direction and parallel to the Y-direction and is rotatable about an axis of rotation extending parallel to the Z-direction. In operation, reaction forces of the actuator units **115**, **117** of the displacement units **39**, **41** directed parallel to the X-direction and/or parallel to the Y-direction are transmitted via the X-motors **61**, **63** and the Y-motors **65**, **67**, **69**, **71** to the balancing unit **119**, reaction forces of the X-motors **61**, **63** of the displacement units **39**, **41** directed parallel to the X-direction and/or parallel to the Y-direction are transmitted via the Y-motors **65**, **67**, **69**, **71** to the balancing unit **119**, and reaction forces of the Y-motors **65**, **67**, **69**, **71** of the displacement units **39**, **41** directed parallel to the X-direction and/or parallel to the Y-direction are directly transmitted to the balancing unit **119**. Since the balancing unit **119** is guided over the further guiding surface **131** by means of the static gas bearings **129**, **135**, said reaction forces are substantially completely converted into relatively small displacements of the balancing unit **119** in directions parallel to the X-direction and/or parallel to the Y-direction and into relatively small rotations of the balancing unit **119** about said axis of rotation extending parallel to the Z-direction. In this manner, mechanical vibrations, which may be caused by said reaction forces in the base **133** and which may be transmitted to the granite block **47** and the substrate holders **21**, **23** of the lithographic device **105** and to the frame **1** of the lithographic device, are prevented as much as possible, so that the positioning accuracy of the displacement system **35** of the positioning device **105** is further improved.

It is noted that another type of displacement unit may be used in the positioning device according to the invention instead of the displacement units **39**, **41** used in the positioning devices **3**, **105** described before. For example, the displacement units of the positioning device may each alternatively comprise a single linear X-motor and a single linear Y-motor for large-distance displacements of the relevant object holder and an actuator unit solely comprising an X-Lorentz-force motor and a Y-Lorentz-force motor for small-distance displacements of the relevant object table.

It is further noted that the invention also relates to lithographic devices in which an exposure process following the step-and-scan principle is applied. Such a lithographic device is provided with a further positioning device by means of which the mask holder is displaceable in a scan direction which is parallel to, for example, the X-direction. According to the stepand-scan process, the mask and the semiconductor substrate are not in fixed positions relative to the focusing unit during the exposure process but are displaced simultaneously in the scan direction, so that the pattern present on the mask is scanned.

It is finally noted, that a positioning device according to the invention may be used not only in a lithographic device but also in other devices where two object tables have to perform a series of positioning steps simultaneously and independently from each other. Examples are finishing machines, machine tools, and other machines or devices in which an object to be machined or processed is first characterized relative to an object holder in a characterization position and is subsequently machined or processed in an operational position.

What is claimed is:

1. A positioning device for a lithographic apparatus, comprising:

a guiding surface extending parallel to an X-direction and parallel to a Y-direction;

a first object holder and a second object holder which are each adapted to be guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position; and

a displacement system constructed and arranged to displace the first object holder and the second object holder over the guiding surface,

wherein the displacement system comprises a first displacement unit and a second displacement unit to which the first object holder, and the second object holder can be coupled alternately, the first displacement unit being suitable for displacing the object holders from the first position into an intermediate position between the first position and the second position, and the second displacement unit being suitable for displacing the object holders from the intermediate position into the second position.

2. A positioning device as claimed in claim **1**, wherein the first and second displacement units each comprise an X-motor having a first part extending parallel to the X-direction and a second part which is displaceable along the first part of the X-motor and can be coupled alternately to the first object holder and to the second object holder, and two Y-motors each having a first part extending parallel to

the Y-direction and a second part which is displaceable along the first part of the relevant Y-motor, the first part of the X-motor of each displacement unit being connected to the second parts of the two Y-motors of the relevant displacement unit.

3. A positioning device as claimed in claim **2**, wherein the first parts of the Y-motors of the two displacement units are connected to a common balancing unit which is guided relative to a base of the positioning device so as to be displaceable parallel to the X-direction and parallel to the Y-direction and to be rotatable about an axis of rotation extending perpendicularly to the X-direction and the Y-direction.

4. A positioning device as claimed in claim **1**, wherein the object holder each comprise a basic part which is guided over the guiding surface and adapted to be coupled to the displacement units, and an object table which is displaceable relative to the basic part by an actuator unit of the relevant object holder.

5. A positioning device as claimed in claim **4**, wherein the object table of each of the object holders is displaceable relative to the basic part parallel to the X-direction, parallel to the Y-direction, and parallel to a Z-direction extending perpendicularly to the X-direction and the Y-direction, and is pivotable relative to the basic part about a first pivot axis extending parallel to the X-direction, a second pivot axis extending parallel to the Y-direction, and a third pivot axis extending parallel to the Z-direction.

6. A positioned device as claimed in claim **1**, wherein said first and second object holders are first and second substrate holders, respectively.

7. A lithographic device comprising:

a radiation source;

a mask [bolder] *holder*;

a focusing unit having a main axis;

a characterization unit; and

a positioning device comprising:

a guiding surface extending parallel to an X-direction, which is perpendicular to the main axis, and parallel to a Y-direction, which is perpendicular to the X-direction and this main axis,

a first substrate holder and a second substrate holder which are each guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position which is near the focusing unit, and

a displacement system constructed and arranged to displace the first substrate [bolder] *holder* and the second substrate holder over the guiding surface,

wherein the displacement system comprises a first displacement unit and a second displacement unit to which the first substrate holder and second substrate holder can be coupled alternately, the first displacement unit being suitable for displacing the substrate holders from the first position into an intermediate position between the first position and the second position, and the second displacement unit being suitable for displacing the substrate holders from the intermediate position into the second position, and

wherein the first position of the substrate holders is a characterization position which is present near the characterization unit.

8. A lithographic device as claimed in claim **7**, wherein the first and second displacement units each comprise an X-motor having a first part extending parallel to the X-direction and a second part which is displaceable along the first part of the X-motor and can be coupled alternately to the first substrate holder and to the second substrate holder, and two Y-motors each having a first part extending parallel to the Y-direction and a second part which is displaceable along the first part of the relevant Y-motor, the first part of the X-motor of each displacement unit being connected to the second parts of the two Y-motors of the relevant displacement unit.

9. A lithographic device as claimed in claim **8**, wherein the first parts of the Y-motors of the two displacement units are connected to a common balancing unit which is guided relative to a base of the positioning device so as to be displaceable parallel to the X-direction and parallel to the Y-direction and to be rotatable about an axis of rotation extending perpendicularly to the X-direction and the Y-direction.

10. A lithographic device as claimed in claim **7**, wherein the substrate holders each comprise a basic part which is guided over the guiding surface and can be coupled to the displacement units, and a substrate table which is displaceable relative to the basic part by means of an actuator unit of the relevant substrate holder.

11. A lithographic device as claimed in claim **10**, wherein the substrate table of each of the substrate holders is displaceable relative to the basic part parallel to the X-direction, parallel to the Y-direction, and parallel to the Z-direction extending perpendicularly to the X-direction and the Y-direction, and is pivotable relative to the basic part about a first pivot axis extending parallel to the X-direction, a second pivot axis extending parallel to the Y-direction, and a third pivot axis extending parallel to the Z-direction.

12. A positioning device for a lithographic apparatus, comprising:

a guiding surface extending parallel to an X-direction and parallel to a Y-direction;

a first object holder and a second object holder which are each adapted to be guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position;

a displacement system constructed and arranged to displace the first object holder and the second object holder over the guiding surface;

wherein the displacement system comprises a first displacement unit and a second displacement unit to which the first object holder and the second object holder can be coupled alternately so that the first object holder and the second object holder switch positions;

wherein the first and second displacement units each comprise an X-motor having a first part extending parallel to the X-direction and a second part which is displaceable along the first part of the X-motor and can be coupled alternately to the first object holder and to the second object holder, and two Y-motors each having a first part extending parallel to the Y-direction and a second part which is displaceable along the first part of the relevant Y-motor, the first part of the X-motor of each displacement unit being connected to the second parts of the two Y-motors of the relevant displacement unit; and

wherein the first parts of the Y-motors of the two displacement units are connected to a common balancing unit which is guided relative to a base of the positioning device so as to be displaceable parallel to the X-direction and parallel to the Y-direction and to be rotatable about an axis of rotation extending perpendicularly to the X-direction and the Y-direction.

13. A positioning device for a lithographic apparatus, comprising:

a guiding surface extending parallel to an X-direction and parallel to a Y-direction;

a first object holder and a second object holder which are each adapted to be guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position;

a displacement system constructed and arranged to displace the first object holder and the second object holder over the guiding surface;

wherein the displacement system comprises a first displacement unit and a second displacement unit to which the first object holder and the second object holder can be coupled alternately so that the first object holder and the second object holder switch positions;

wherein the object holders each comprise a basic part which is guided over the guiding surface and adapted to be coupled to the displacement units, and an object table which is displaceable relative to the basic part by an actuator unit of the relevant object holder; and

wherein the object table of each of the object holders is displaceable relative to the basic part parallel to the X-direction, parallel to the Y-direction, and parallel to a Z-direction extending perpendicularly to the X-direction and the Y-direction, and is pivotable relative to the basic part about a first pivot axis extending parallel to the X-direction, a second pivot axis extending parallel to the Y-direction, and a third pivot axis extending parallel to the Z-direction.

14. A positioning device for a lithographic apparatus, comprising:

a guiding surface extending parallel to an X-direction and parallel to a Y-direction;

a first object holder and a second object holder which are each adapted to be guided over the guiding surface and are each displaceable parallel to the X-direction and parallel to the Y-direction from a first position into a second position;

a displacement system constructed and arranged to displace the first object holder and the second object holder over the guiding surface;

wherein the displacement system comprises a first displacement unit and a second displacement unit to which the first object holder and the second object holder can be coupled alternately so that the first object holder and the second object holder switch positions; and

wherein said first and second object holders are first and second substrate holders, respectively.

15. A positioning method for performing operations on substrates in a lithographic device, comprising:

moving first and second substrate holders over a two-dimensional plane between a first position into a second position with first and second displacement units;

loading and characterizing a substrate in the first position;

exposing and unloading the substrate in the second position;

the first and second displacement units moving the first substrate holder and the second substrate holder over the guiding surface between the first and second positions using connections that can be coupled and uncoupled so that the substrate holders switch positions.

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