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**Datasheet for the decision
of 8 November 2012**

Case Number: T 1543/08 - 3.4.03

Application Number: 03250316.1

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Title of invention:
Stage system

Applicant:
CANON KABUSHIKI KAISHA

Headword:
-

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

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Case Number: T 1543/08 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 8 November 2012

Appellant:
(Applicant)

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Decision under appeal:

Decision of the Examining Division of the
European Patent Office posted 10 March 2008
refusing European patent application
No. 03250316.1 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: G. Eliasson
Members: R. Q. Bekkering
P. Mühlens

Summary of Facts and Submissions

I. This is an appeal against the refusal of application 03 250 316 for lack of an inventive step, Article 56 EPC 1973, over documents

D1: EP 0 977 244 A

D2: EP 0 502 578 A.

II. At oral proceedings before the board, the appellant applicant requested that the decision under appeal be set aside and a patent granted on the basis of the following:

Main request:

Claims 1 to 18 of the main request filed with the letter dated 8 October 2012;

First auxiliary request:

Claims 1 to 18 of the first auxiliary request filed with the letter dated 8 October 2012;

Second auxiliary request:

Claims 1 to 16 of the second auxiliary request filed with the letter dated 8 October 2012.

III. Claim 1 of the main request reads as follows:

"A stage system, comprising:
a movable stage (152);
a force applying mechanism (157) including an
electromagnet (158) for applying, by use of said
electromagnet (158), a force to said stage in a
direction of a magnetic flux generated by said
electromagnet(158);
a moving mechanism (159, 161) for moving said
electromagnet (158) in a movement direction of said
stage (152); and
an acceleration profile generator (103) for generating
an acceleration profile describing a relation between
time and acceleration to be produced by said moving
mechanism (159, 161) at corresponding time;
a moving mechanism controller (131, 133) for
controlling said moving mechanism based on an output of
said acceleration profile generator;
characterized by
a magnetic-flux profile generator (104) for generating
a magnetic-flux profile describing a relation between
time and a magnetic flux to be produced by said
electromagnet (158) at corresponding time;
a detector (142) for detecting a magnetic flux signal
of said electromagnet; and
a magnetic-flux controller (143) for controlling a
magnetic flux of said electromagnet based on an output
of said detector and an output of said magnetic-flux
profile generator (104), wherein the magnetic-flux
profile generator (104) is arranged to produce a
profile, wherein a square of the magnetic flux of the
magnetic-flux profile is proportional to the
acceleration of the acceleration profile."

- IV. Claim 1 of the first auxiliary request corresponds to claim 1 of the main request with the following addition inserted before the last feature:

"wherein said moving mechanism controller comprises a feed forward controller, and".

- V. Claim 1 of the second auxiliary request corresponds to claim 1 of the first auxiliary request with the following addition:

"wherein the stage system further comprises a Lorentz's force generating mechanism (402-414) for generating Lorentz's force in said stage, wherein said Lorentz's force generating mechanism is arranged to apply a force to said stage from at least two sides of said stage".

- VI. Moreover, all requests include a further independent claim directed at a stage system with a force generating mechanism configured to generate a moment and a force in plural axial direction.

- VII. The appellant in substance provided the following arguments:

Neither document D1 nor document D2 disclosed a control based on a magnetic flux profile. According to document D2, the reaction forces and thus the signals U_{f1} to U_{f3} were generated in order to counter-act against a momentary movement of the whole lithographic device. A profile in the sense as described in the claims and in the application meant a scheduled plan on how the magnetic flux should change over time. Such a kind of

profile, however, could not be provided by the measures as defined in document D2.

Hence, the subject-matter of independent claims 1 and 9 according to the main request, as well as that of the independent claims of the first and second auxiliary request, was both new and inventive over documents D1 and D2.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

2.1 *Novelty*

2.1.1 *Document D1*

As acknowledged by the appellant, a stage system according to the pre-characterising portion of claim 1 is known from D1 (cf column 8, line 40 to column 14, line 30 and figures 1, 2).

In particular, document D1 discloses a stage system comprising in the terminology of claim 1 a stage system comprising:

a movable stage (101);

a force applying mechanism including an electromagnet (108) for applying, by use of said electromagnet (108), a force to said stage in a direction of a magnetic flux generated by said electromagnet (108);

a moving mechanism (112, 113) for moving said electromagnet (108) in a movement direction of said stage (101); and
an acceleration profile generator (123) for generating an acceleration profile describing a relation between time and acceleration to be produced by said moving mechanism (112, 113) at corresponding time (cf column 12, lines 41 to 49);
a moving mechanism controller (136, 137) for controlling said moving mechanism based on an output of said acceleration profile generator.

The differences over D1 are defined in the characterising portion of claim 1.

In particular, document D1 does not disclose

- a magnetic-flux profile generator for generating a magnetic-flux profile describing a relation between time and a magnetic flux to be produced by said electromagnet at corresponding time;
- a detector for detecting a magnetic flux signal of said electromagnet; and
- a magnetic-flux controller for controlling a magnetic flux of said electromagnet based on an output of said detector and an output of said magnetic-flux profile generator;
- wherein the magnetic-flux profile generator is arranged to produce a profile, wherein a square of the magnetic flux of the magnetic-flux profile is

proportional to the acceleration of the acceleration profile.

- 2.1.2 In the decision under appeal it was held that "because the current profile output from the D1 acceleration profile producing means 123 and the correcting means 132 corresponds to a magnetic-flux density profile and because this magnetic-flux density profile equals the magnetic-flux density profile output from the magnetic-flux profile generator 104 of the application to within a scaling factor, the D1 acceleration profile producing means 123 and the correcting means 132 can be considered a magnetic-flux profile generator" (reasons 9.3).

According to document D1 "The attraction feed-forward (FF) system 131 is a control system for producing combined thrust between the magnetic material plate 107 and the paired electromagnets 108, which thrust is proportional to the output of the acceleration profile producing means 123. The attraction FF system 131 comprises correcting means 132, adjusting means 133 and two electromagnet current amplifiers 134. The electromagnet current amplifiers 134 serve to energize the coils 108a of the electromagnets 108, independently of each other. The correcting means 132 functions to correct non-linear relationship between the electric current and attraction force of the electromagnet 108, and it includes a square root calculator. Generally, the attraction force of an electromagnet is proportional to a square of the electric current to the electromagnet. The attraction force to be produced to drive the stage 101 is a force which is proportional to the output of the acceleration profile producing means.

Therefore, once the square root of the output of the acceleration profile producing means 123 is detected and it is taken as a designating signal, an attraction force proportional to the square of the square root of the output of the acceleration profile producing means 123 can be produced" (cf column 10, lines 32 to 55).

As essentially argued by the appellant, since in D1 the magnetic flux not only depends on the current but also on μ and the gap between the electromagnet (158) and the magnetic material plate (157), in particular the gap varying in an uncontrolled manner during acceleration/deceleration, the current profile output of D1 does not correspond to a magnetic-flux density profile.

2.1.3 Accordingly, the subject-matter of claim 1 of the main request is new with respect to document D1 (Article 54(1) EPC 1973).

The subject-matter is also new with respect to the remaining available prior art which is more remote.

2.2 *Inventive step*

2.2.1 As discussed above and as would be readily apparent to a person skilled in the art, in D1 the magnetic flux and thereby the force applied to the stage by the electromagnet during acceleration/deceleration depends on the clearance between the electromagnet (158) and the magnet material plate (157). As this clearance may vary, controlling the acceleration/deceleration of the stage as well as its position may be inaccurate.

Accordingly, the objective problem to be solved relative to D1 is to improve the accuracy of the control of the stage position and movement.

- 2.2.2 As argued in the decision under appeal, a person skilled in the art would readily notice these undesired variations of the clearance and the resulting inaccuracies in stage position and movement. Accordingly, the definition of the problem would be obvious to a skilled person.

Moreover, a skilled person would also readily appreciate that the cause of the problem lies in the inadequate control in D1 of the force acting on the stage during acceleration/deceleration, and thus of the magnetic flux of the electromagnet.

- 2.2.3 In an attempt to solve the above problem, the skilled person would refer to document D2, which, in the context of stage systems for semiconductor manufacturing equipment such as lithographic equipment, addresses the problem of controlling the force exerted by an electromagnet on a plate in case of a varying air gap between the electromagnet and the plate (cf column 14, lines 4 to 20).

In particular, according to document D2 "The value of the electromagnetic force exerted by each of the electromagnets 157, 159 and 161 is regarded as proportional to the square of the value of an electric current through the relevant electromagnet 157, 159, 161 and inversely proportional to the square of the size of the air gap 163. If the size of the air gap 163 changes owing to a small movement of the carrier 139

relative to the base 131, the value of the electromagnetic force will change unless further measures are taken. The use of the electromagnets 157, 159 and 161 as force actuators, whereby each of the electromagnets 157, 159 and 161 exerts a force on the base 131 whose value is determined by the controller 167 of the control system 165, is accordingly only possible if the current through the electromagnets 157, 159 and 161 is controlled" (cf column 14, lines 4 to 20; figures 6 and 8).

- 2.2.4 The solution suggested by D2 is the provision of a detector (211, 213, 215) for detecting the magnetic flux signal of the electromagnet and a corresponding feed back control circuit (227, 229, 231) adjusting the current through the electromagnet and thereby the force exerted by the electromagnet on the plate (cf column 14, lines 21 to column 16, line 52; figures 6 and 8).

In particular, according to D2 "Fig. 8 also shows that the negative feedback line 229 comprises an electronic integrator 231 by means of which the output signal U_{mf1} of the flux density transducer 211 is integrated to a signal U_{b1} whose value is proportional to the magnetic flux density B_{m1} . The input signal U_{b1} of the comparator 227, therefore, is a signal whose value is proportional to a measured value of the flux density B_{m1} , while the input signal U_{hdf1} , whose value is equal to the square root of the desired force F_{em1} , is proportional to a desired value of the flux density B_{m1} . An output signal U_{com} of the comparator 227 is equal to the difference $U_{hdf1} - U_{b1}$ of the two input signals of the comparator 227" (cf column 15, line 49 to column 16, line 4; figure 8).

2.2.5 Applying the solution suggested in D2 to the stage system of D1, the skilled person would include in the attraction force control system of D1 a feedback control based on the detected magnetic flux of the electromagnet.

Accordingly, the skilled person would include a detector for detecting a magnetic flux signal of the electromagnet, as per claim 1.

2.2.6 Moreover, in order for the comparator as part of the feedback control to have an appropriate signal to compare with detected magnetic flux of the electromagnet, it would be obvious to the skilled person to provide as input signal a magnetic flux signal. Indeed, as is the case in D2 and would be readily apparent to the skilled person, both inputs of the comparator of the feedback control circuit should relate to the same physical parameter for comparison.

2.2.7 The appellant argued that document D2 did, however, not disclose a magnetic flux profile. According to document D2, the reaction forces and thus the signals U_{f1} to U_{f3} were generated in order to counter-act against a momentary movement of the whole lithographic device. A profile in the sense as described in the claims and in the application meant a scheduled plan on how the magnetic flux should change over time. Such a kind of profile, however, could not be provided by the measures as defined in document D2.

2.2.8 In document D1, an acceleration profile is used as input signal for the control system of the electromagnets. In particular, as indicated in D1,

"Figure 2 is a block diagram of a control system for drive controlling the stage system. It comprises movement target specifying means 121 for creating a movement target for the stage 101, position profile producing means 122 for generating the relationship between the time and the stage target position corresponding to that time, on the basis of the created target, and acceleration profile producing means 123 for generating the relationship between the time and the acceleration to be provided during that time, on the basis of the created target" (cf column 9, lines 35 to 45). Moreover, according to D1, "Generally, the attraction force of an electromagnet is proportional to a square of the electric current to the electromagnet. The attraction force to be produced to drive the stage 101 is a force which is proportional to the output of the acceleration profile producing means. Therefore, once the square root of the output of the acceleration profile producing means 123 is detected and it is taken as a designating signal, an attraction force proportional to the square of the square root of the output of the acceleration profile producing means 123 can be produced" (cf column 10, lines 45 to 55).

Accordingly, the acceleration profile determines the force to be exerted by the electromagnet as a function of time.

As taught in D2, however, the magnetic flux of the electromagnet more accurately reflects the force exerted by the electromagnet.

It would, therefore, be obvious to the skilled person to generate a magnetic flux profile instead,

determining the force to be exerted by the electromagnet as a function of time.

Accordingly, it would be obvious to the skilled person to provide in the system of D1 a magnetic-flux profile generator for generating a magnetic-flux profile describing a relation between time and the magnetic flux to be produced by the electromagnet at corresponding time, as defined in claim 1.

Furthermore, as is generally known and disclosed in D2, the square of the magnetic flux is proportional to the force exerted by the electromagnet on the stage and thereby proportional to the acceleration of the stage. Accordingly, the square of the magnetic flux of the magnetic-flux profile is proportional to the acceleration of the acceleration profile, as per claim 1.

2.2.9 Finally, it would be obvious to the skilled person to provide a magnetic flux controller, corresponding to the comparator suggested in D2, for controlling the magnetic flux of the electromagnet based on the output of the detector and the output of the magnetic-flux profile generator, as per claim 1.

2.2.10 Accordingly, the subject-matter of claim 1 according to the main request is obvious to a person skilled in the art and, therefore, lacks an inventive step in the sense of Article 56 EPC 1973.

2.2.11 *Independent claim 9*

A stage system according the pre-characterising portion of claim 9 is also known from document D1 (cf figures 8 to 12 and corresponding description). The differences over D1 are defined in the characterising portion of claim 9.

As for claim 1 discussed above, the objective problem to be solved relative to D1 is to improve the accuracy of the control of the stage position and movement. The solution as claimed is rendered obvious by document D2 for essentially the same reasons given for claim 1.

Accordingly, also the subject-matter of claim 9 according to the main request is obvious to a person skilled in the art and, therefore, lacks an inventive step in the sense of Article 56 EPC 1973.

2.2.12 The appellant's main request is, therefore, not allowable.

3. *First auxiliary request*

Claim 1 according to the first auxiliary request contains, with respect to claim 1 of the main request, the additional feature "*wherein said moving mechanism controller comprises a feed forward controller*".

This feature is also known from the same embodiment discussed above of D1 (cf column 12, lines 45 to 49). Accordingly, it does not alter the finding of lack of inventive step above.

Accordingly, the subject-matter of claim 1 according to the first auxiliary request is obvious to a person skilled in the art for in substance the same reasons given above and, therefore, lacks an inventive step in the sense of Article 56 EPC 1973.

The same applies to independent claim 9 of the first auxiliary request.

The appellant's first auxiliary request is, therefore, not allowable either.

4. *Second auxiliary request*

Claim 1 according to the second auxiliary request contains, with respect to claim 1 of the first auxiliary request, the additional feature *"wherein the stage system further comprises a Lorentz's force generating mechanism (402-414) for generating Lorentz's force in said stage, wherein said Lorentz's force generating mechanism is arranged to apply a force to said stage from at least two sides of said stage"*.

The appellant argued at the oral proceedings that the basis for this amendment was the description as originally filed stating with reference to the embodiment depicted in figure 1 *"There is a pair of electromagnet units (Lorentz's force producing mechanism) having electromagnets 158 which are disposed to sandwich the magnetic material plate 157 therebetween"* (cf page 13, lines 22 to 26).

Accepting the appellant's argument in this respect, thereby leaving aside any clarity deficiencies stemming

from the fact that the claim fails to make clear that the claimed mechanism is not an additional means but merely a further specification of the already defined force applying mechanism including an electromagnet (158), that the reference numerals (402-414) are incorrect as they refer to parts of a linear motor of another unrelated embodiment in the application shown in figures 4 and 5, and that the reference to a Lorentz force in the context of an electromagnet exerting a force on a plate is at least confusing, it is noted that the above feature does not add anything inventive. It is known from document D1 to provide the force applying mechanism with electromagnets on both sides of the plate so that it can apply a force to the stage from two sides (cf column 9, lines 6 to 9 and figures 1 and 2).

The subject-matter of claim 1 according to the second auxiliary request is, thus, also obvious to a person skilled in the art and, therefore, lacks an inventive step in the sense of Article 56 EPC 1973.

The appellant's second auxiliary request is, therefore, not allowable either.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar:

Chair:

S. Sánchez Chiquero

G. Eliasson