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(72) Inventor: **Amerio, Aldo**  
**15033 Casale Monferrato (AL) (IT)**

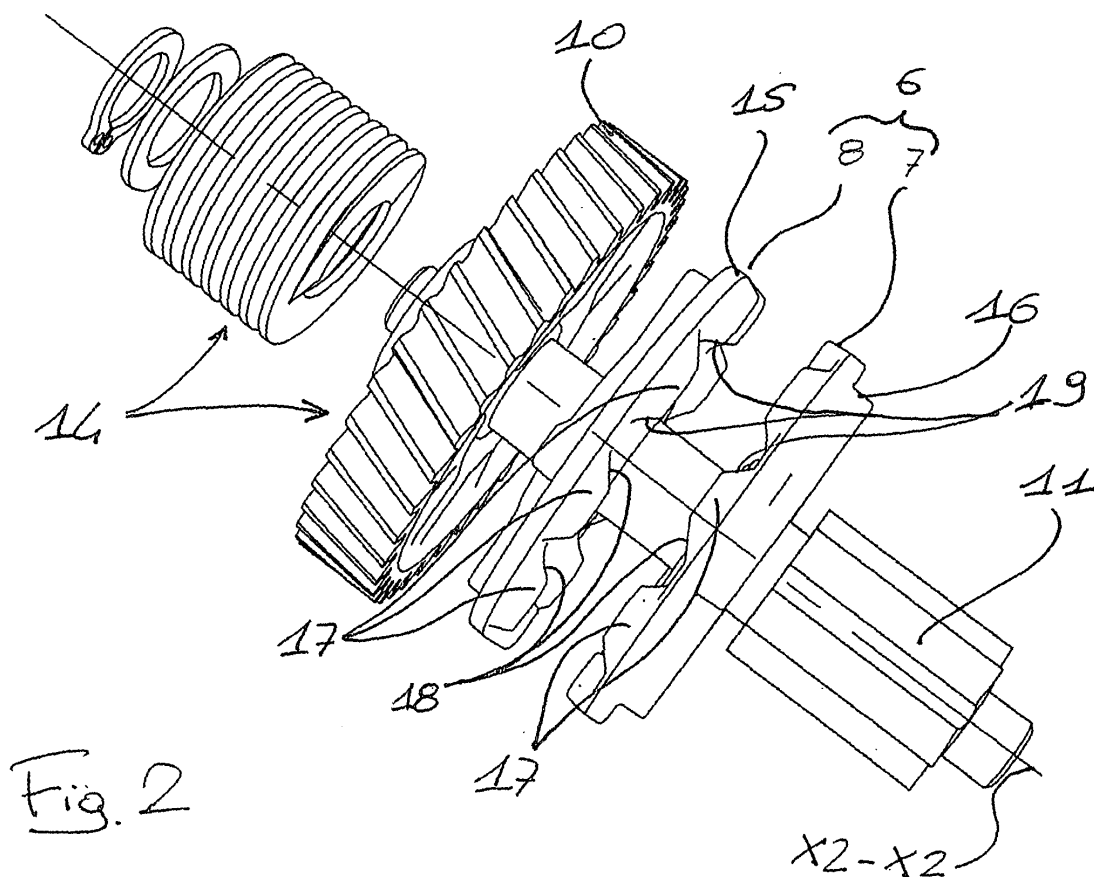
(74) Representative: **Simino, Massimo et al**  
**Perani Mezzanotte & Partners**  
**Piazza S. Babila, 5**  
**20122 Milano (IT)**

(71) Applicant: **Sesamo S.r.l.**  
**15030 Terruggia (AL) (IT)**

(54) **Automatic system for swinging doors**

(57) This invention relates to a device (1) for opening and closing swinging leaves comprising a motor (2) provided with a drive shaft (3) located along a first axis (X1-X1), a reduction unit (4) located along a second axis (X2-X2) and capable of receiving the rotation of the drive shaft

(3) and transmitting it to an output shaft (5) in which the reduction unit (4) comprises an asymmetrical coupling (16), or in which the reduction unit (4) comprises a toothed insert (6) comprising two toothed surfaces (7, 8), facing each other.



## Description

**[0001]** This invention relates to an automatic system for swinging doors, that is a device for automating the operations of opening and closing swinging doors.

**[0002]** Unlike spring-loaded door closing devices, in which the manual thrust of opening the door powers the spring for subsequent automatic closure, these automatic systems are active devices capable of both opening and closing doors on their own.

**[0003]** Generally they are provided with command and control means combined with suitable sensors to open the door when a person is ready to pass through it and close it immediately afterwards.

**[0004]** If swinging doors have a leaf weighing less than 150-180 kg and a width not exceeding 1200-1600 mm they can be defined as being "light". Such doors find particular application in entrances for pedestrians, for example for offices or shops.

**[0005]** The dimensions and weight of the door therefore determine the maximum torque which must be capable of being transmitted to the operating arm in order to move the door, and therefore the measuring of the entire automatic system.

**[0006]** Automatic systems for swinging doors essentially comprise a driving electric motor and a reduction unit connected thereto which transmits the rotation of the motor to an arm operating the door.

**[0007]** These components, together with the command and control electronics, the power supply means for the motor and/or any back-up batteries, are located in a suitable housing which is generally installed above the door itself, and is visible to passers by.

**[0008]** The motor is generally an electric motor with a rotation speed of the order of 1000-2000 r.p.m. and the reduction unit must therefore reduce this rotation speed to values capable of controlling the movement of the leaf, both when accelerating and when braking.

**[0009]** In order to reduce the dimensions of the automatic system as much as possible resort may be had to a worm-gearwheel coupling between the electric motor and the reduction unit so as to greatly reduce the number of rotations in a single pass.

**[0010]** However this arrangement renders the automatic system particularly sensitive to those "traumatic" events which create peak stress in the gears, such as for example impact by the leaf against objects or persons, thrusts, which may be violent, opposing the movement of the leaf, or thrusts on the leaf beyond the limits of its travel.

**[0011]** In fact a worm-gearwheel coupling is not suitable for reversing the transmission of forces and therefore the application of an external force to the door opposite that exerted by the automatic system at that moment runs the risk of causing structural failure of one of the gears in the force transmission chain.

**[0012]** In view of the state of the art described, the object of this invention is to provide a device for swinging

leaves provided with a reduction unit which can overcome at least some of the problems mentioned above, while at the same time maintaining the properties of high reliability and regular operation.

**[0013]** According to this invention this object is achieved through a device according to claim 1.

**[0014]** Further advantages will be apparent from the description of preferred embodiments corresponding to the dependent claims.

**[0015]** The features and advantages of this invention will be apparent from the following detailed description of an embodiment provided by way of a non-restrictive example with reference to the appended drawings, in which:

- Figure 1 shows an isometric exploded view of a device according to one embodiment of this invention,
- Figure 2 shows an exploded isometric view of part of the device in Figure 1,
- Figure 3 shows a diagrammatical view partially in cross-section of the reduction unit in Figure 2 when it is not transmitting rotation,
- Figure 4 shows a diagrammatical view in partial cross-section of the reduction unit in Figure 3 when transmitting rotation.

**[0016]** With reference to the figures, 1 indicates the device (an automatic system) for opening and closing swinging leaves as a whole.

**[0017]** Device 1 comprises a motor 2 equipped with a drive shaft 3 rotating about a first axis X1-X1, the reduction unit 4 rotating about a second axis X2-X2 and capable of receiving the rotation of drive shaft 3 and transmitting it to an output shaft 5 and a torque limiter.

**[0018]** To operate the door, the output shaft can be connected to the operating arm, which may be either a rigid articulated arm connected so as to operate the door from the side opposite that from which it is opened, or a moving pulling arm to operate the door from the side on which it is opened.

**[0019]** In the embodiment in Figure 1 the torque limiter comprises a toothed coupling 6, comprising two toothed surfaces 7, 8 facing each other.

**[0020]** Motor 2 is connected to reduction unit 4 through a coupling comprising a worm 9 which engages a toothed wheel 10, advantageously made of a yielding material, such as for example bronze, an aluminium alloy, a low alloy steel or a polymer material, preferably selected from the group comprising polyacetal or polyamide resins, such as for example POM or PA.

**[0021]** Toothed wheel 10 can rotate about second axis X2-X2, which may advantageously be perpendicular to first axis X1-X1.

**[0022]** In the dynamic chain of reduction unit 4, located immediately after the coupling between worm 9 and toothed wheel 10 are the torque limiter, constructed as a coupling 6, and then a second toothed wheel 11 and a third toothed wheel 12 constituting the second and final

toothed connection to reduce the rotation speed of motor 2 to values compatible with the speeds for opening and closing leaves.

**[0023]** The arm operating the swinging leaf may be mounted on output shaft 5, of one piece with third toothed wheel 12 and rotating about third axis of rotation X3-X3, which is advantageously parallel to second axis of rotation X2-X2.

**[0024]** Thrust means 14 are mounted on second rotation axis X2-X2, in addition to first and second toothed wheels 10, 11 and coupling 6, in order to keep coupling 6 normally engaged, exercising an axial force F in the direction of second axis of rotation X2-X2.

**[0025]** Advantageously the axial force exerted by thrust means 14 is determined in such a way as to permit coupling 6 to disengage before the coupling between first toothed wheel 10 and worm 9 or another coupling in the drive chain transmitting the motion of toothed wheel 10 to the arm operating the door gives way.

**[0026]** As may be seen in Figure 2, toothed wheel 10 is located between thrust means 14 and disk 15 of coupling 6.

**[0027]** Thrust means 14 may advantageously comprise a spring, for example a helical spring.

**[0028]** In this case, because the helical spring acts on toothed wheel 10 and toothed wheel 10 acts on disk 15 of coupling 6, thrust means 14 more properly comprise both the spring and toothed wheel 10.

**[0029]** As will be seen, the embodiment illustrated in the figures is particularly compact; in particular the use of a coupling comprising worm 9 makes it possible to achieve a high reduction in rotation speed and to use only one further coupling instead of two as in other known devices.

**[0030]** Toothed wheel 10 which engages worm 9 does not have teeth located in a radial direction, but teeth inclined with respect to axis of rotation X2-X2; worm 9 therefore also exerts a force F2 directed along second axis of rotation X2-X2 on toothed wheel 10.

**[0031]** This force is vectorially added to force F1 exerted by the spring and increases or decreases axial force F acting on coupling 6 to press the two disks 15 and 16 together, depending upon the direction of rotation.

**[0032]** By comparing Figures 3 and 4 it will be seen that in the embodiment illustrated toothed wheel 10 and disk 15 of coupling 6 are mounted in such a way as to move in an axial direction with respect to second axis of rotation X2-X2, at least over a distance such as to permit the two disks 15 and 16 to disengage.

**[0033]** It will be noted that in Figures 3 and 4 the teeth of toothed wheel 10 are represented as radial teeth, purely for clarity of drawing.

**[0034]** Coupling 6 may therefore be asymmetrical, so as to compensate for this effect and provide a limiting value for the torque beyond which coupling 6 is no longer able to transmit rotation regardless of the direction of rotation in motor 2.

**[0035]** By "asymmetrical coupling" is meant here a

coupling comprising two elements pressed together, in which the ratio between the force with which the two elements are pressed together and the maximum torque which can be transmitted by the coupling also depends on the direction of the torque which is transmitted to the coupling.

**[0036]** Hypothetically considering two elements pressed together with the same force in two directions, coupling 6 according to this invention would transmit a torque up to a first threshold value in one direction and up to a second threshold value, different from the first, in the opposite direction.

**[0037]** By suitably dimensioning the two threshold values it is possible to make the overall behaviour of device 1 independent of the direction of the transmitted torque, that is the direction of rotation of motor 2 (opening or closing the door).

**[0038]** As may more clearly be seen in Figure 2, toothed surfaces 7, 8 may face each other frontally and be constructed on two disks 15, 16 located in planes which are parallel to each other and perpendicular to second axis of rotation X2-X2.

**[0039]** Toothed surfaces 7, 8, which can be seen in the figures, each comprise nine teeth 17, but a different number of teeth is possible, for example, four, six, ten, twelve, sixteen or more.

**[0040]** Lateral surfaces 18, 19 of teeth 17 are advantageously oblique; teeth 17 illustrated in the figures have a trapezoidal profile comprising a surface 20 parallel to the plane of disks 15, 16 located between lateral surfaces 18, 19.

**[0041]** In the preferred embodiment illustrated teeth 17 are asymmetric; for example, oblique surfaces 18, 19 may have a different inclination with respect to the plane of disks 15, 16 or, in other words, with respect to second axis of rotation X2-X2.

**[0042]** The asymmetric behaviour of coupling 16 is therefore provided by the asymmetry of teeth 17 themselves, in the preferred embodiment described with reference to the drawings.

**[0043]** In the embodiment illustrated in the Figures the inclination of surface 18 with respect to a plane perpendicular to second axis of rotation X2-X2 is 33°, while that of surface 19 is 50°; however it is clearly conceivable that these angles may be varied, for example the first between 20° and 45° and the second between 40° and 60°, depending upon the geometry and dynamics of the coupling between worm 9 and toothed wheel 10.

**[0044]** Clearly device 1 comprises a suitable housing which may in turn comprise a portion indicated by 21 in Figure 1 which is intended for reduction unit 4 only.

**[0045]** Coupling 6 may advantageously be made of metal material, such as zinc-based alloys, for example Zama alloy.

**[0046]** Although the automatic system according to this invention has been described in combination with a swinging door, its use is not intended to be restricted to these, but may clearly also be extended to swinging

leaves or any other element which can be advantageously driven by a device such as that described and/or claimed.

**[0047]** Similarly, the helical spring part of thrust means 14 may be replaced by equivalent elements, such as for example other types of mechanical spring, or hydraulic or gas springs.

**[0048]** Obviously in order to satisfy contingent and specific requirements a person skilled in the art could apply many modifications and variants to the configurations described above, all of which however are included within the scope of protection of the invention as defined by the following claims.

## Claims

1. Device (1) for automating the operations of opening and closing swinging leaves comprising:

- a motor (2) provided with a drive shaft (3) located along a first axis (X1-X1).
- a reduction unit (4) located along a second axis (X2-X2) and capable of receiving the rotation of said drive shaft (3) and transmitting it to an output shaft (5)

### characterised in that

said reduction unit (4) comprises a torque-limiting coupling (6).

2. Device (1) according to the preceding claim, in which said coupling (6) is asymmetric.
3. Device (1) according to either of the preceding claims, in which said coupling (6) comprises two toothed surfaces (7, 8) facing each other.
4. Device (1) according to the preceding claim, in which said toothed surfaces (7, 8) are flat surfaces frontally facing each other provided on two disks (15, 16) located in planes which are parallel to each other.
5. Device (1) according to either of claims 3 or 4, in which said toothed surfaces (7, 8) each comprise from four to sixteen teeth (17).
6. Device (1) according to any one of claims 3 to 5, in which the teeth (17) of said toothed surfaces (7, 8) are trapezoidal.
7. Device (1) according to any one of claims 3 to 6, in which the teeth (17) of said toothed surfaces (7, 8) are asymmetrical.
8. Device (1) according to any one of the preceding claims, in which:

- said drive shaft (3) transmits rotation to a toothed wheel (10) of said reduction unit (4) through a worm (9),

- said device (1) comprises thrust means (14) to exert an axial force F which enables said coupling (6) to transmit a torque up to a limit value,

- said toothed wheel (10) is part of said thrust means (14) in that said worm (9) exerts an axial force on said toothed wheel (10),

- because of the force exerted by said worm (9) on said toothed wheel (10), said axial force F exerted by said thrust means (14) on said coupling (6) differs depending upon the direction of rotation of said worm (3),

- said coupling (6) is such as to compensate for the different axial force F acting upon it in such a way as to have a maximum transmissible torque value which is substantially the same for both directions of rotation of said worm (9).

9. Device (1) according to any one of claims 2 to 8, in which the teeth (17) of said toothed surfaces (6, 7) have a lateral surface (18) which is inclined by an angle of between 20° and 45° with respect to the plane perpendicular to said second axis of rotation (X2-X2).

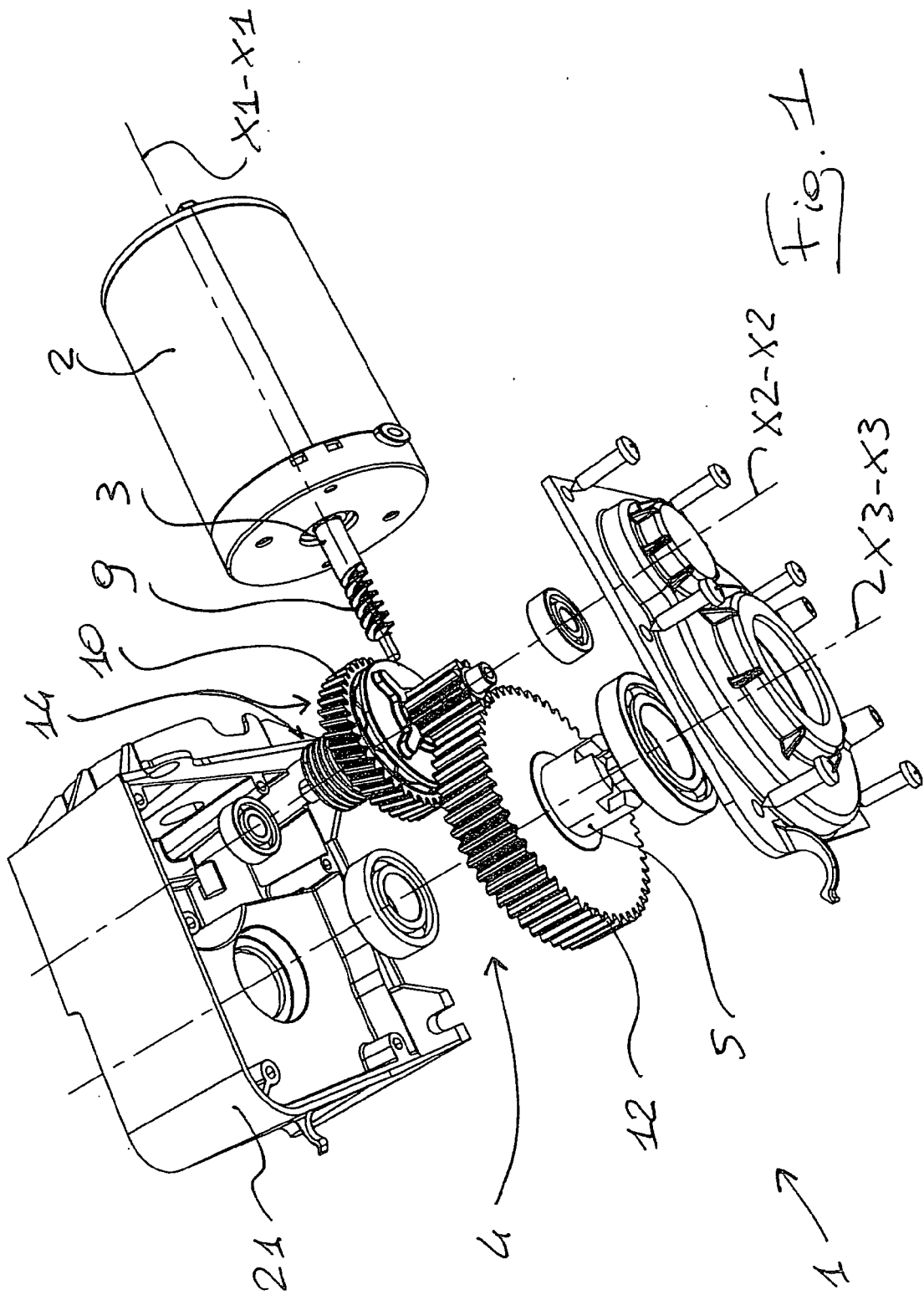
10. Device (1) according to any one of claims 2 to 8, in which the teeth (17) of said toothed surfaces (6, 7) have a lateral surface (19) which is inclined by an angle of between 40° and 60° with respect to the plane perpendicular to said second axis of rotation (X2-X2).

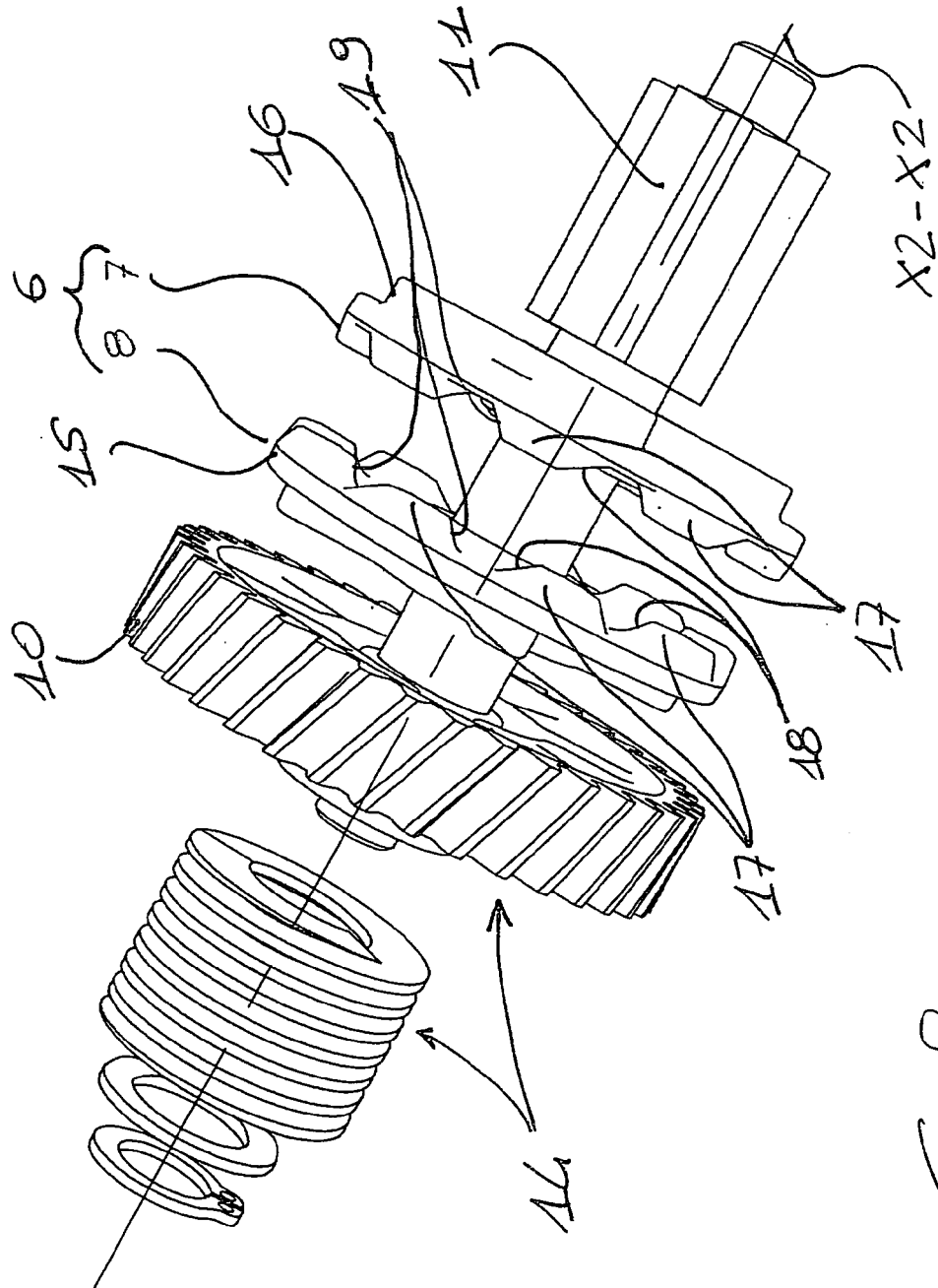
11. Device (1) according to any one of the preceding claims, in which the element receiving the rotation of said drive shaft (3) is a toothed wheel (10) made of yielding material.

12. Device (1) according to any one of the preceding claims, in which said reduction unit (4) comprises a single pair of gears (11, 12) to reduce the rotation speed of said motor (2) downstream from said coupling (6).

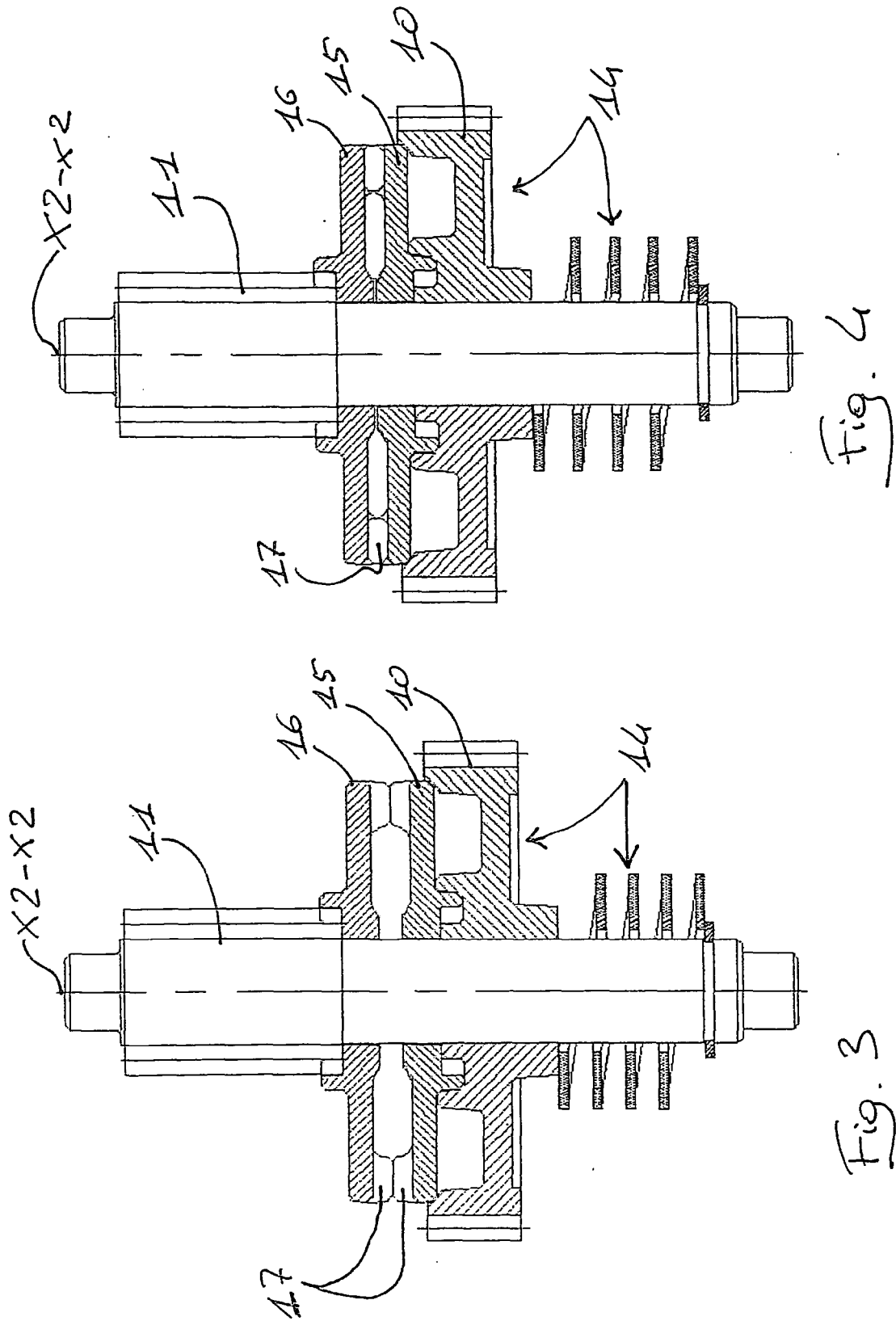
13. Device (1) according to any one of the preceding claims, in which said coupling (6) is kinematically located between said toothed wheel (10) of yielding material and said pair of gears (11, 12).

14. Device (1) according to any one of the preceding claims, in which said first axis of rotation (X1-X1) is perpendicular to said second axis of rotation (X2-X2).





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European Patent  
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# EUROPEAN SEARCH REPORT

Application Number  
EP 07 42 5443

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Y	* column 3, line 13 - column 5, line 39; claim 1; figures 1-5 *	2-7,9-14	
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Y	* paragraph [0014] - paragraph [0029]; claims 1,6; figures 1-6 *	2-7,9-13	
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>12 December 2007</b>	Examiner <b>Balice, Marco</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... &amp; : member of the same patent family, corresponding document</p>			

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EPO FORM 1503 03.82 (P04C01)



**ANNEX TO THE EUROPEAN SEARCH REPORT  
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EP 07 42 5443

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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