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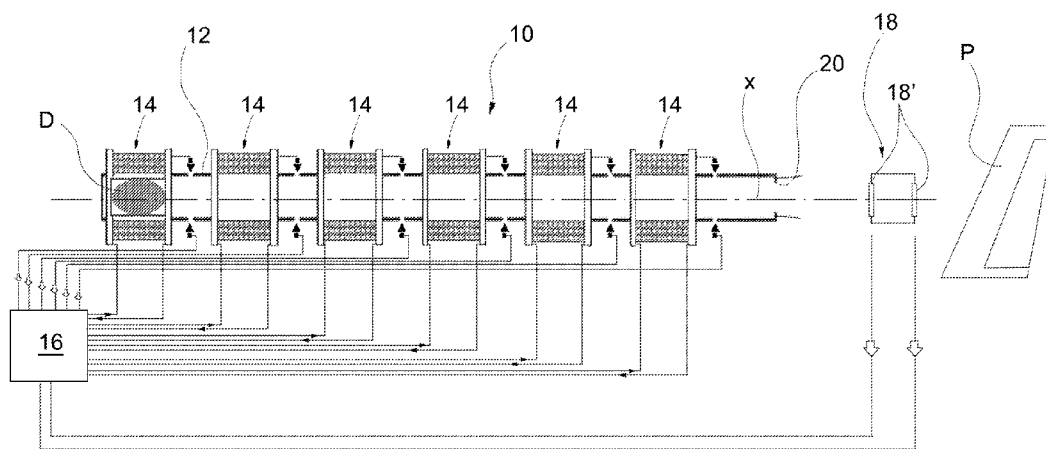


fig.1

(57) Abstract: Testing apparatus (10) for testing a bird strike on an aircraft part (P), comprising: a hollow, rectilinear duct (12) along a longitudinal direction (x) to accommodate coaxially therein a cylindrical bolt (D) with a metal casing to be accelerated for the test simulating a bird strike; a plurality of accelerating devices (14), arranged on the duct (12) in consecutive positions along the longitudinal direction (x), each adapted, when activated, to exert an electromagnetic force on the bolt (D) to accelerate it in the longitudinal direction (x); an electronic control unit (16); and a speed sensor (18), to measure the speed of the bolt (D) along the longitudinal direction (x), after it has been accelerated by all the accelerating devices (14), wherein the electronic control unit (16) is configured to control the activation of each of the accelerating devices (14), based on the measurement signal received by the speed sensor (18).

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Testing apparatus for performing bird strike tests and the related method

The present invention relates in general to a testing apparatus for tests simulating a bird strike on aircraft parts.

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Subjecting aircraft parts to tests simulating a bird strike is a necessity dictated by the stringent aviation safety regulations. Indeed, before it may be used in the construction of an aircraft, each aircraft part (for example a wing, a tailplane, a fuselage section, a movable surface such as a wing or an elevator) must undergo specific bird strike tests for the part to be certified.

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Current instruments used for the structural verification of aircraft parts subjected to bird strikes generally use a lot of energy, whether mechanical or pneumatic. Generally, such systems comprise an accelerating duct, in which a cylindrical bolt, having a bottom surface enclosed by a polystyrene cap and adapted to accommodate within it a test bird, is accelerated by pressurized air and then pneumatically actuated. Upon exiting the accelerating duct, the bolt is eviscerated by a device called a 'stripper' before the bird strikes the aircraft part under test.

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Among the most common problems with the current instruments used for tests simulating a bird strike, the following become particularly apparent:

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- the danger to people working adjacent to the instruments, in which high-pressure air is used and stored for use in the pneumatic system;

- the risk of air leakage between the bolt being accelerated and the inner walls of the accelerating duct;

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- the formation of condensation due to air expansion, which prevents the test from being properly observed or filmed during execution;

- thermal expansions of the instrument;

- the use of a system (pneumatic), which is cumbersome and expensive;

- the presence of moisture induced by the external environment and penetrating within the accelerating duct.

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The object of the present invention is, therefore, to improve the reliability and accuracy of bird strike testing required for the certification of aircraft parts and to provide a related testing apparatus and method that is an alternative to that of the prior art and that does not suffer from some or all of the disadvantages of the prior art.

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This and other objects are fully achieved according to the present invention by a testing apparatus as defined in the accompanying independent claim 1 and a testing method simulating a bird strike on an aircraft part as defined in the accompanying independent claim 10.

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Advantageous embodiments of the invention are specified in the dependent claims, the content of which is to be understood as being an integral part of the following description.

In summary, a first aspect of the invention is based on the idea of providing a testing apparatus for tests simulating a bird strike on an aircraft part, the testing apparatus comprising:

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- a hollow, rectilinear duct extending along a longitudinal direction, adapted to accommodate therein a bolt to be accelerated for test simulating a bird strike, the bolt being cylindrical and having a metal casing adapted to accommodate a bird, and being arranged coaxially to said longitudinal direction (x);

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- a plurality of accelerating devices, arranged on the duct in consecutive positions along the longitudinal direction, each accelerating device being adapted to, when activated or powered, exert an electromagnetic force on the bolt to accelerate it in the longitudinal direction;

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- an electronic control unit;
- a speed sensor, adapted to measure the speed of the bolt along the longitudinal direction, in a measurement position, after it has been accelerated by all the accelerating devices, to generate a signal representative of such measurement and send it to the electronic control unit;

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wherein the electronic control unit is configured to control the activation of each of the accelerating devices, based on the signal received from the speed sensor.

According to an embodiment of the first aspect of the invention, each accelerating device comprises a plurality of magnetic coils wound about the duct and coaxial with the longitudinal direction.

- 5 According to an embodiment of the first aspect of the invention, the accelerating devices are arranged equally spaced along the longitudinal direction.

According to an embodiment of the first aspect of the invention, the speed sensor is adapted to measure the speed component of the bolt in a measurement position that is
10 arranged at the aircraft part and/or that is arranged just outside the duct or at an exit section of the bolt from the duct, for example after the stripper.

According to an embodiment of the first aspect of the invention, the electronic control unit is configured to control the activation of each of the accelerating devices by controlling the
15 moment of activation of each of the accelerating devices, and/or the time interval between the activation of one accelerating device and the immediately adjacent accelerating device, and/or the time interval during which each of the accelerating devices remains activated.

Also forming part of the invention, according to a second aspect of the invention, is a
20 method for calibrating a testing apparatus according to the first aspect of the invention, comprising the steps of:

- a) providing a testing apparatus according to the first aspect of the invention;
- b) loading a test bolt in the duct, placing it at the first one of the accelerating devices, or the accelerating device placed farthest from an exit section of the duct;
- 25 c) commanding, by means of the electronic control unit, the sequential activation of the accelerating devices, preferably controlling the sequential activation in a coordinated manner;
- d) by means of the speed sensor, measuring the speed of the test bolt along the longitudinal direction, at the measurement position, after it has been accelerated by all the
30 accelerating devices, generating a signal representative of such measurement and sending it to the electronic control unit.

Also forming part of the invention, according to a third aspect of the invention, is a testing method simulating a bird strike on an aircraft part, the method comprising the steps of:

- a) providing a testing apparatus according to the first aspect of the invention;
- x1) carrying out a calibration method according to the second aspect of the invention;
- x2) placing an aircraft part in front of the duct, namely, facing an exit section of the duct;
- x3) loading a bolt to be accelerated into the duct, placing it at the first one of the accelerating devices and arranging it coaxially to the longitudinal direction; the bolt being cylindrical and having a metal casing wherein a bird is accommodated;
- x4) commanding, by means of the electronic control unit, the sequential activation of the accelerating devices, wherein the electronic control unit controls such activation based on the signal representative of the measurement received following said step d);
- x5) by means of the speed sensor, measuring the speed of the bolt along the longitudinal direction (x), at the measurement position (x1), after it has been accelerated by all the accelerating devices, generating a signal representative of such measurement and sending it to the electronic control unit.

Further features and advantages of the present invention will appear more clearly from the following detailed description, given by way of non-limiting example, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic view of a testing apparatus according to an embodiment of the first aspect of the invention; and

Fig. 2 is a detail view of a section of the duct of the testing apparatus in Fig. 1, in which the detail of an accelerating device is also visible.

With reference to the figures, a testing apparatus according to the invention is indicated generally with 10. As mentioned above, a testing apparatus 10 is used for tests simulating a bird strike on an aircraft part P, such as a fin or a wing panel.

The testing apparatus 10 essentially comprises a duct 12, a plurality of accelerating devices

14, an electronic control unit 16, and a speed sensor 18.

The duct 12 is a hollow, rectilinear duct, essentially a tube. It extends along a longitudinal direction x , which is also the direction along which the bolt D to be accelerated is accelerated to launch it against the aircraft part P and to simulate a bird strike in the test method. In particular, the duct 12 is adapted to accommodate within it the bolt D: the bolt D is essentially cylindrical, and comprises a metal casing adapted to accommodate within it a bird. The bolt D is arranged coaxially with the longitudinal direction x , as mentioned, within the duct 12.

The duct 12 has an opening 20 adapted to allow the bolt D or a part thereof to pass. For example, the opening 20 may be such that it blocks the passage to the metal casing of the bolt D and allows instead the bird contained within the bolt D to pass. In this way, it is possible to dispense with the stripper of the prior art with obvious savings in cost and complexity of the testing apparatus 10 with respect to the prior art.

The accelerating devices 14 are arranged on the duct 12, one after the other along the longitudinal direction x , preferably so that they are spaced equally from each other, and preferably so that their position along the longitudinal direction x is adjustable.

Preferably, the accelerating devices 14 are all the same, but this is not essential to the invention.

Each of the accelerating devices 14 is adapted, when activated, commanded, or operated, to exert an electromagnetic force on the bolt D, so as to accelerate it in the longitudinal direction x . As shown in Fig. 2, the accelerating devices 14 for this purpose each preferably comprise a plurality of magnetic coils 22 wound about the duct 12 coaxially to the longitudinal direction x and which are adapted to generate a magnetic field (represented by the arrow B) when a current I passes through them. Since the bolt D comprises a metal casing, such magnetic field results in the generation of an accelerating force on the metal casing that accelerates the bolt D in the longitudinal direction x . In a manner known per se, for this purpose, each accelerating device 14 may be associated with

an RLC circuit that stores energy in a respective capacitor and yields it to the bolt D as kinetic energy.

5 The speed sensor 18 is adapted to measure the speed of the bolt D, or at least of the component thereof along the longitudinal direction x, in a measurement position x1, which may be, for example, at the aircraft part P or substantially almost in contact therewith, or which may be arranged just outside the duct 12 or just outside the opening 20 that allows the bolt D to exit from the duct 12. However, the measurement position x1 is such that the bolt D, when it reaches said measurement position, has already been accelerated by all the
10 accelerating devices 14, or it has already overtaken all the accelerating devices 14 from its initial position, or in the position in which the bolt D is still stationary in the duct 12 and is being moved along the longitudinal direction x. As a result of the measurement, the speed sensor 18 is adapted to generate a signal representative of the measurement and send it to the electronic control unit 16. In a manner known per se, the speed sensor 18 may comprise
15 a pair of photocells 18', arranged one after the other along the longitudinal direction x, at a short, predetermined distance.

The electronic control unit 16 is an electronic processing unit adapted to store, process, transmit, and receive signals representative of information and/or data. According to the
20 invention, the electronic processing unit 16 is configured to control the activation of each of the accelerating devices 14, or to individually control the activation of each of the accelerating devices 14, also based on one or more signals received from the speed sensor 18, which was generated in the same testing method or which was generated in a previous method for calibrating the testing apparatus 10. "Controlling activation," in the present
25 document, may be understood, for example, to mean controlling the moment of activation, and thus the sequence of activation, of each of the accelerating devices 14, and/or controlling the time interval between the activation of one accelerating device 14 and the immediately adjacent accelerating device 14, or the subsequent one, and/or controlling the time interval in which each of the accelerating devices 14 remains activated. Clearly other
30 modes of control based on other control parameters are also possible, as well as a combination of the proposals disclosed and those known per se to a person skilled in the art, without departing from the scope of the invention.

Furthermore, a part of the present invention is a method for carrying out said bird strike tests on the aircraft part E.

- 5 More specifically, the method for carrying out bird strike tests on an aircraft part E according to the present invention comprises the steps of:
- a) providing a testing apparatus 10 according to the first aspect of the invention;
 - b) loading a test bolt D, also known as a ‘dummy’ bolt, in the duct 12, placing
10 it at the first one, or at one of, the accelerating devices 14;
 - c) commanding, by means of the electronic control unit 16, the sequential activation of the accelerating devices 14;
 - d) by means of the speed sensor 18, measuring the speed of the test bolt D along the longitudinal direction x, at the measurement position x1, after it has been
15 accelerated by all the accelerating devices 14, or after it has exited the duct 12, generating a signal representative of such measurement and sending it to the electronic control unit 16;
 - x2) placing an aircraft part P in front of the duct 12;
 - x3) loading a bolt D to be accelerated into the duct 12, placing it at the first one
20 of the accelerating devices 14 and arranging it coaxially to the longitudinal direction x;
 - x4) commanding, by means of the electronic control unit 16, the sequential activation of the accelerating devices 14, based on the signal representative of the measurement signal received following step d) in the calibration method;
 - x5) by means of the speed sensor 18, measuring the speed of the bolt D along
25 the longitudinal direction x, at the measurement position x1, after it has been accelerated by all the accelerating devices 14, or after it has exited the duct 12, generating a signal representative of such measurement and sending it to the electronic control unit 16.

Ultimately, it is clear that the testing method for simulating bird strikes described above is
30 a method for using the testing apparatus 12 according to the first aspect of the invention.

As may be seen from the foregoing description, a testing apparatus according to the present

invention and a related method allow the disadvantages of the prior art to be overcome.

In particular, with such an apparatus, dangerous accumulations of pneumatic or elastic energy are avoided.

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Furthermore, by virtue of the accelerating devices according to the invention, the friction between the bolt and the accelerating duct is negligible.

Moreover, by virtue of the testing apparatus, air leakage is irrelevant to the impact and finally no moisture or condensation forms that would prevent – as is the case with the prior art – observing or filming the test.

Without prejudice to the principle of the invention, the embodiments and construction details may vary widely with respect to that which has been described and illustrated purely by way of non-limiting example, without thereby departing from the scope of protection of the invention as defined in the appended claims.

LIST OF REFERENCE NUMBERS

20	P	aircraft part
	D	bolt
	x	longitudinal direction
	10	testing apparatus
	12	duct
25	14	accelerating devices
	16	electronic control unit
	18	speed sensor
	18'	photocells
	20	opening
30	22	coils

CLAIMS

1. Testing apparatus (10) for tests simulating a bird strike on an aircraft part (P), the testing apparatus (10) comprising:

5 - a hollow, rectilinear duct (12) extending along a longitudinal direction (x), adapted to accommodate therein a bolt (D) to be accelerated for the test simulating a bird strike, the bolt (D) being cylindrical and having a metal casing adapted to accommodate a bird, and being arranged coaxially with said longitudinal direction (x);

 - a plurality of accelerating devices (14), arranged on the duct (12) in consecutive positions along the longitudinal direction (x), each accelerating device (14) being adapted to, when activated, exert an electromagnetic force on the bolt (D) to accelerate it in the longitudinal direction (x);

 - an electronic control unit (16); and

10 - a speed sensor (18), adapted to measure the speed of the bolt (D) along the longitudinal direction (x), in a measurement position (x1), after it has been accelerated by all the accelerating devices (14), and to generate a signal representative of such measurement and send it to the electronic control unit (16);

 wherein the electronic control unit (16) is configured to control the activation of each of the accelerating devices (14), based on the signal received by the velocity sensor (18).

2. Testing apparatus according to claim 1, wherein each accelerating device (14) comprises a plurality of magnetic coils (22) wound about the duct (12) and coaxially with the longitudinal direction (x).

3. Testing apparatus according to claim 1 or to claim 2, wherein the accelerating devices (14) are arranged equally spaced along the longitudinal direction (x).

4. Testing apparatus according to any of the preceding claims, wherein the velocity sensor (18) is adapted to measure the speed component of the bolt (D) in a measurement position (x1) arranged at the aircraft part (P).

5. Testing apparatus according to any of the preceding claims, wherein the speed sensor (18) is adapted to measure the speed component of the bolt (D) in a measurement position (x1) arranged just outside the duct (12) or at an opening (20) that allows the bolt (D) to exit from the duct (12).

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6. Testing apparatus according to any of the preceding claims, wherein the electronic control unit (16) is configured to control the activation of each of the accelerating devices (14) by controlling the time moment each of the accelerating devices (14) is activated.

10 7. Testing apparatus according to any of the preceding claims, wherein the electronic control unit (16) is configured to control the activation of each of the accelerating devices (14) by controlling the time interval between the activation of an accelerating device (14) and the immediately adjacent accelerating device (14).

15 8. Testing apparatus according to any of the preceding claims, wherein the electronic control unit (16) is configured to control the activation of each of the accelerating devices (14) by controlling the time interval wherein each of the accelerating devices (14) stays activated.

20 9. Calibration method of a testing apparatus (10) according to any of the preceding claims, comprising the steps of:

a) providing a testing apparatus (10) according to any of the preceding claims;

b) loading a test bolt (D) in the duct (12), placing it at the first one of the accelerating devices (14);

25 c) commanding, by means of the electronic control unit (16), the sequential activation of the accelerating devices (14);

d) by means of the speed sensor (18), measuring the speed of the test bolt (D) along the longitudinal direction (x), at the measurement position (x1), after the test bolt has been accelerated by all the accelerating devices (14), generating a signal representative of
30 such measurement and sending it to the electronic control unit (16).

10. Testing method simulating a bird strike on an aircraft part (P), the method compris-

ing the steps of:

- a) providing a testing apparatus (10) according to any claim from 1 to 8;
- x1) carrying out a calibration method according to claim 9;
- x2) placing an aircraft part (P) in front of the duct (12);
- 5 x3) loading a bolt (D) to be accelerated in the duct (12), placing it at the first one of the accelerating devices (14) and arranging it coaxially with the longitudinal direction (x); the bolt (D) being cylindrical and having a metal casing wherein a bird is accommodated;
- x4) commanding, by means of the electronic control unit (16), the sequential ac-
- 10 tivation of the accelerating devices (14), wherein the electronic control unit (16) controls such activation based on the signal representative of the measurement received following said step d);
- x5) by means of the speed sensor (18), measuring the speed of the bolt (D) along the longitudinal direction (x), at the measurement position (x1), after the bolt has
- 15 been accelerated by all the accelerating devices (14), generating a signal representative of such measurement and sending it to the electronic control unit (16).

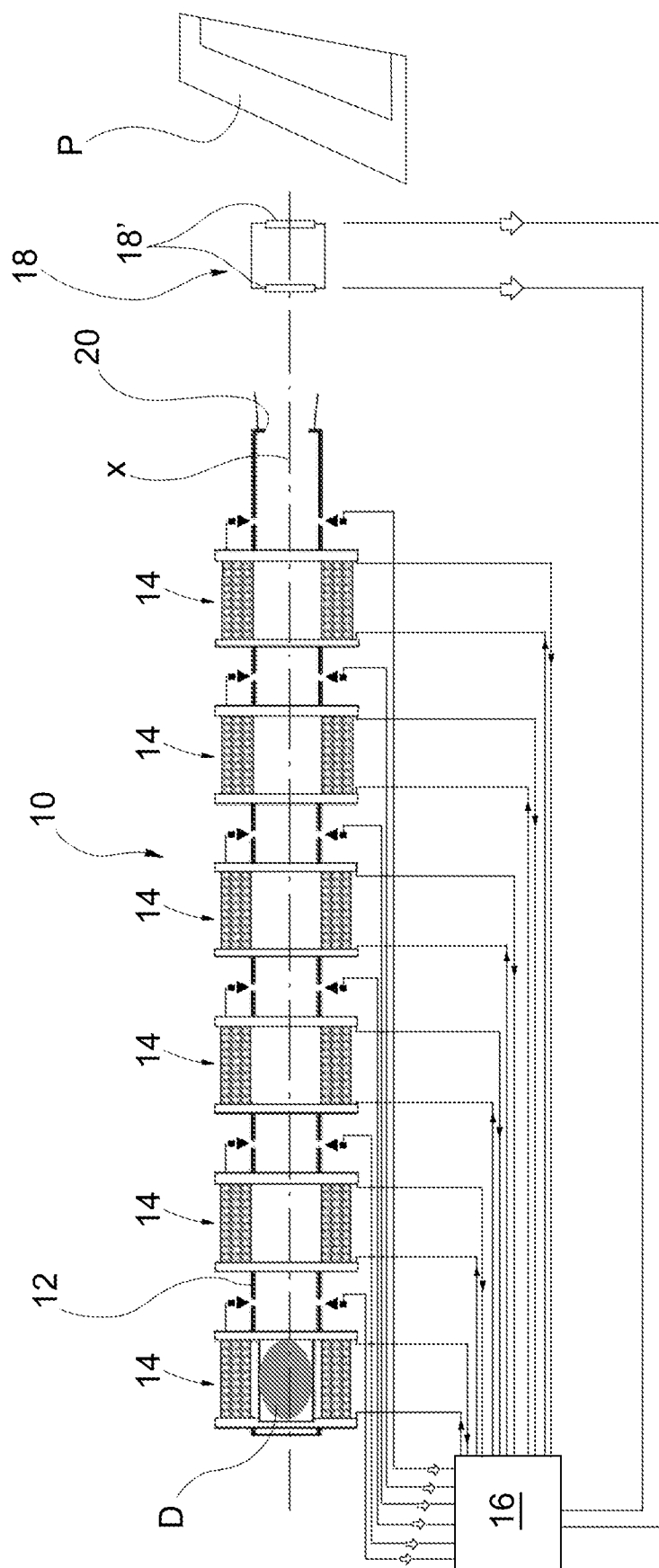


fig. 1

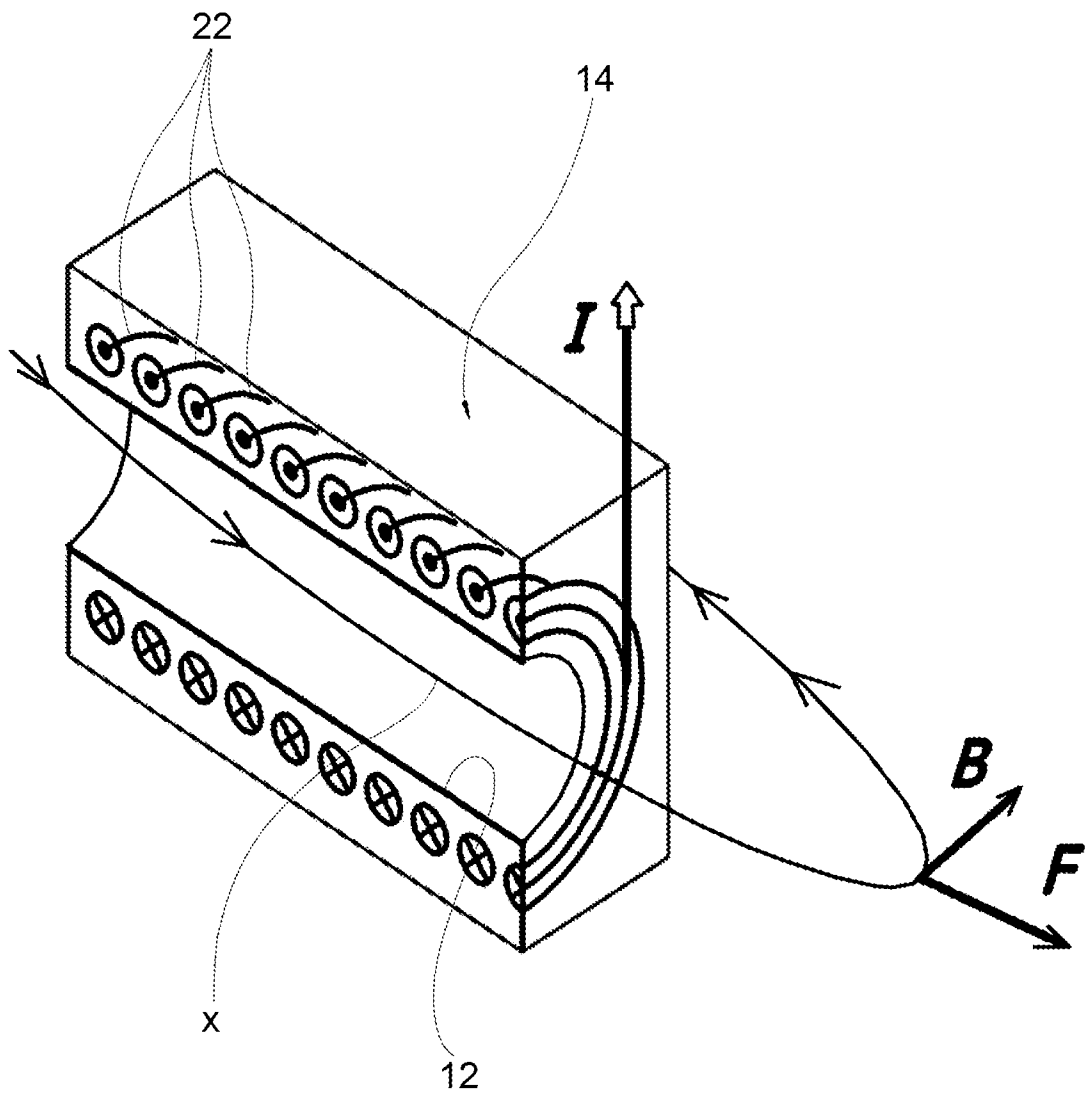


fig.2

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER INV. G01M7/08 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) G01M		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 113 049 205 A (SHAANXI DAGONG XUHANG ELECTROMAGNETIC TECH CO LTD) 29 June 2021 (2021-06-29) Fig. 1-2 and corresponding relevant text in the description. -----	1 - 10
A	CN 109 813 517 A (UNIV XIAN TECHNOLOGICAL) 28 May 2019 (2019-05-28) Fig. 1-3 and corresponding relevant text in the description. -----	1 - 10
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 6 August 2024		Date of mailing of the international search report 12/08/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Oppo, Carla Ivana

INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 113049205 A	29-06-2021	CN 113049205 A	29-06-2021
		CN 117554017 A	13-02-2024

CN 109813517 A	28-05-2019	NONE	
