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(54) **Title**: DRAWING MACHINE AND DRAWING METHOD

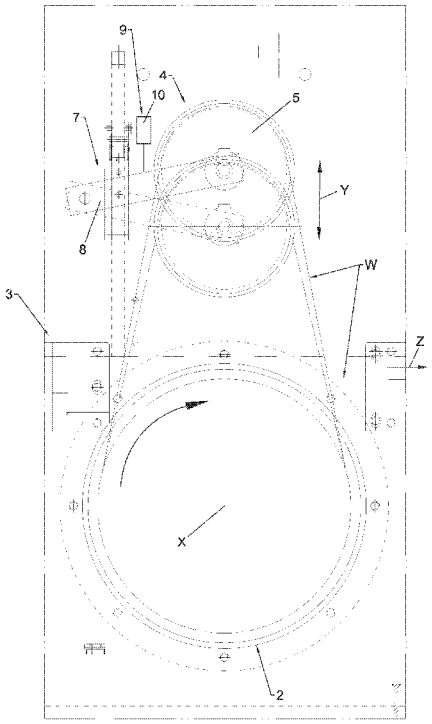

Fig.2

(57) **Abstract**: Drawing machine (1) comprising capstans (2) for pulling a metal wire (W) arranged in succession and alternated with dies (3), elastically yieldable tensioning means (4) for applying a tensioning force to a first portion of the wire (W) at contact with a first capstan (2), means for adjusting the rotation speed of the first capstan (2) in response to the change of the geometric configuration of the tensioning means (4), a sensor unit for measuring the peripheral speed of the first capstan (2) and the advancement speed of the wire (W) in the first portion, an adjustment system that increases the tensioning force upon detecting a difference between the advancement speed and the peripheral speed. The invention also relates to a method for drawing a metal wire.

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DRAWING MACHINE AND DRAWING METHOD

DESCRIPTION

The present invention regards a machine for drawing metal wires and a method for drawing a metal wire.

As known, drawing is a process that consists in pulling a metal wire through a succession of matrices, called dies, with progressively decreasing section to reduce the diameter of the wire to a predefined value.

In a drawing machine of the known type, the dies are alternated with pulling capstans around which the wire is wound and which are driven in rotation to drag the wire in question.

Drawing conditions do not remain constant over time due to the dimensional tolerances of the diameter of the wire, the progressive wear of the dies and other factors.

Thus, in order to maintain the correct tension of the wire through the dies there arises the need to adapt the speed of the wire to the drawing conditions and this occurs through a feedback system which regulates the capstans rotation speed in real time.

In a first known embodiment, for example described in document CA 712892 A, the feedback system comprises a dancer device arranged between each capstan and the die immediately downstream and it comprises two idle pulleys with variable distance between centres and around which the wire is loop-wound and which are forced to move away from each other so as to maintain the wire tensioned.

A change of the speed of the wire tends to change the tension thereof and thus changes the distance between the two pulleys, which is detected by a sensor.

A control system connected to the sensor adjusts the speed of the corresponding capstan so as to stabilise the pulleys around a new balanced position.

The aforementioned feedback system has the sure advantage of absorbing the speed change of the wire until the speed of the capstan adjusts suitably.

However, the feedback system described above reveals the drawback of not eliminating the sliding of the wire in the direction of the axis of the capstan, due to the fact that the entry point and exit point of the wire wound around each capstan are arranged on different planes, between which the turns of the wire are required to move during the advancement.

The axial sliding reveals the drawback of creating unwanted marks on the wire, reducing the quality of the product, and leading to an early wear of the capstans.

The axial sliding is particularly marked in the so-called "dry" machines, in which the wire is cooled by contact between the latter and the capstan and they thus require a high number of turns around each capstan to guarantee a sufficient contact surface.

A fixed axis idle pulley alongside each capstan, which serves for detaching the turns, is known to be used in an effort to eliminate the axial sliding.

More precisely, the wire is wound for a portion of a turn around the capstan, thus around the aforementioned pulley and lastly around a capstan for a further turn portion.

The axis of the pulley is inclined with respect to the capstan axis so as to divert the wire from the first turn portion to the second turn portion in the direction of the capstan axis so as to eliminate the axial sliding.

The feedback system described above is particularly suitable for the so-called "oil bath" machines, in which the removal of heat from the wire is guaranteed by the presence of oil and which, thus, require a limited number of wire turns around each capstan.

In this feedback system, the idle pulley may be coupled to a speed transducer to measure the speed of the wire, enabling avoiding the use of the dancer and directly adjusting the speed of the capstans depending on the speed of the wire, so as to avoid tangential sliding.

However, basically, the electromechanical tolerances of the transducer, as well as the possible tangential sliding of the wire on the idle pulleys and on the capstans deriving from loss of tension of the wire, limit the actual speed measurement precision of this system, which thus does not guarantee the complete elimination of tangential sliding.

An object of the present invention is to overcome all the aforementioned drawbacks of the prior art.

In particular, an object of the invention is to provide a drawing machine that enables eliminating the tangential sliding of the wire on the capstans.

Another object of the present invention is to provide a machine that also enables eliminating the axial sliding.

Another object of the invention is to provide a machine having a limited

construction complexity.

The aforementioned objects are attained by a drawing machine according to claim 1 and a drawing method according to claim 13.

Further detailed characteristics of the invention are outlined in the relative dependent claims.

Advantageously, the reduction of the sliding of the wire on the capstan enables reducing the machining defects of the wire with respect to what can be obtained with the prior art machines, obtaining a higher quality product.

The aforementioned objects and the advantage, alongside others to be mentioned hereinafter, shall be outlined in the description of a preferred embodiment of the invention, provided solely by way of non-limiting example, with reference to the attached drawings wherein:

- fig. 1 schematically represents a drawing machine according to the invention, in front view;
- fig. 2 represents an enlarged detail of fig. 1, showing a pulling capstan and the relative wire tensioning means;
- fig. 3 represents the detail of fig. 1, in lateral view.

The metal wires drawing machine of the invention is indicated in its entirety in fig. 1 with reference **1**.

The machine **1** comprises a drawing line consisting in a succession of pulling capstans **2** around which a wire **W** is wound and between which corresponding dies **3** are interposed.

Each capstan **2** is associated to drive means for the rotation thereof, not represented but per se known, so as to pull the wire **W** through the die **3** arranged immediately upstream according to the advancement direction **Z** of the wire.

The dies **3** have respective passage sections decreasing along the drawing line so that, upon passing through each die **3**, the wire **W** is subjected to a corresponding reduction of the section.

The machine **1** also comprises a pilot capstan **11** arranged downstream of the aforementioned succession of pulling capstans **2** and associated to drive means, also not represented but per se known, for the rotation thereof at a pre-settable fixed speed, which determines the advancement conditions of the wire **W** through the drawing line.

Elastically yieldable means **4** for tensioning the wire **W**, suitable to tension the

wire **W** in a portion at contact with a first pulling capstan **2** with a tensioning force, are also present.

Advantageously, the aforementioned tensioning means **4** are capable of temporarily absorbing the speed changes of the wire **W** modifying the geometric configuration thereof and maintaining the wire tensioned.

Furthermore, control means, not represented but per se known, that act on the drive means to adjust the rotation speed of the first pulling capstan **2** in response to the change of the aforementioned geometric configuration of the tensioning means **4**, are also present.

In particular, the control means are configured to increase or reduce the rotation speed of the first pulling capstan **2** following a movement of the tensioning means **4** corresponding to an increase or, respectively, a reduction of the speed of the wire **W**.

Advantageously, the aforementioned control means enable the adjustment of the speed of the first pulling capstan **2** to adapt it to the actual speed of the wire **W**, which may change due to the dimensional tolerances of the die **3** and the wire **W** and the wear of the die **3**.

According to the invention, a sensor unit, not represented but per se known, that determines the peripheral speed of the first pulling capstan **2** and the advancement speed of the aforementioned portion of the wire **W**, is present.

An adjustment system, also not represented but per se known, that increases the tensioning force of the tensioning means **4** upon detecting a difference between the advancement speed of the wire **W** and the peripheral speed of the first capstan **2**, a sign of the presence of tangential sliding of the wire on the first capstan, is also present.

The increase of the tensioning force increases the friction of the wire **W** on the first pulling capstan **2** so as to eliminate the tangential sliding.

Advantageously, the aforementioned adjustment means enable adjusting the tensioning force of the wire **W** to the drawing conditions, thus avoiding having to manually set it at a predefined value.

As a matter of fact, a manually set value could be insufficient and cause the tangential sliding of the wire **W** on the first pulling capstan **2**, or it could be excessive and subject the wire **W** to excessive tension.

On the contrary, the invention enables adapting the tensioning force to the drawing conditions, maintaining it at the minimum value compatible with

absence of tangential sliding.

Preferably and as observable in fig. 2, the tensioning means **4** comprise a first idle pulley **5** which receives the wire **W** exiting from the first pulling capstan **2**, which is rotatably associated to mobile support means **7**.

The aforementioned mobile support means **7** are configured to enable the movement of the first pulley **5** in a displacement direction **Y** orthogonal to the rotation axis **X** of the first pulling capstan **2**.

Figures 1 and 2 represent the two extreme positions that the first pulley **5** may take, in which the upper position is obtained when the support means **7** are arranged in the position represented with a solid line and the lower position is obtained when the support means **7** are arranged in the position represented with a dashed line.

Furthermore, a tensioner device **9** suitable to exert - on the first pulley **5** - the direct tensioning force according to the aforementioned displacement direction **Y** is also present.

The use of the aforementioned first idle pulley **5** as a member for tensioning the wire **W** reveals various advantages.

A first advantage lies in the fact that the first pulley **5** is directly driven in rotation by the wire **W** and, thus, it can also be used for measuring the advancement speed of the wire, hence limiting the number of components of the machine **1**.

The aforementioned speed measurement is preferably carried out through a means for detecting the angular speed of the first pulley **5**, preferably an encoder, belonging to the sensor unit.

If the first pulley **5** is used for measuring the speed of the wire **W**, the comparison between the latter speed and the peripheral speed of the first capstan **2** must be carried out at a constant rotation speed of the capstan **2**, i.e. not during the speed adjustment steps.

As a matter of fact, a speed change of the first capstan **2** depends on the movement of the axis of the first pulley **5** and, thus, the speed of the wire **W** detected by the latter is definitely different from the peripheral speed of the first capstan **2**, though in absence of tangential sliding.

On the contrary, a constant rotation speed of the first capstan **2** corresponds to a stable position of the first pulley **5** and, thus, a difference between the peripheral speed of the first capstan and the one detected for the wire **W** is a

sign of the presence of tangential sliding.

A second advantage related to the use of the aforementioned first pulley **5** lies in enabling to eliminate the axial sliding of the wire **W**.

For this purpose, the first pulley **5** has an inclined rotation axis with respect to the axis **X** of the first capstan **2** and the wire **W** is arranged so as to perform, in the following order: a first turn portion around the first capstan **2**; a revolution portion around the inclined pulley; a second turn portion around the first capstan **2**.

It is clear that the inclination of the axis of the first pulley **5** requires a diversion of the wire **W** so that the first turn portion and the second turn portion around the capstan **2** are unwound on respective different planes according to the axis **X** of the latter, so as to avoid the axial sliding of the wire **W**.

Preferably and as observable in fig. 3, the machine **1** also comprises a second idle pulley **6**, coaxial to the aforementioned first pulley **5**.

Advantageously, the aforementioned second pulley **6** enables winding the wire **W** for a third turn portion around the first capstan **2**, so as to enhance the pulling efficiency of the capstan reducing the relative tension on the wire **W**.

Preferably, the second pulley **6** is rotatably released from the first pulley **5**, so that the two pulleys can rotate at different speeds to adapt to possible speed differences between the respective wire portions, that may occur in particular operative conditions.

This, advantageously, avoids any sliding of the wire **W** on the idle pulleys **5** and **6**.

It is clear that other idle pulleys coaxial to the first pulley **5**, depending on the number of revolution portions of the wire **W** meant to be obtained around the first capstan **2**, may be present.

As regards the means **7** for supporting the first idle pulley **5**, they preferably comprise an oscillating arm **8** provided with a free end on which the first pulley **5**, the possible second idle pulley **6** and further idle pulleys, if present, are fitted.

As regards the tensioner device **9**, it preferably comprises a pneumatic cylinder **10** associated to the oscillating arm **8**.

As concerns means for controlling the speed of the first capstan **2**, they preferably comprise sensor means for detecting a displacement of the first pulley **5** according to the aforementioned displacement direction **Y**.

The aforementioned sensor means, not represented but per se known, preferably comprise a cam associated to the end of the aforementioned oscillating arm **8** opposite to the free end and to which there is faced a sensor that detects the radial overall dimension of the cam so as to determine the angular position thereof.

The control means command the increase or reduction of the rotation speed of the first pulling capstan **2** depending on whether the sensor means detect a displacement of the first pulley **5** in the opposite direction or, respectively, in the same direction as the tensioning force.

Clearly, the description above regarding the first pulling capstan **2**, especially as concerns the means **4** for tensioning the wire **W**, control means, a sensor unit and a system for adjusting the tensioning force, may be similarly applied to each pulling capstan of the machine **1**.

The machine **1** described above also comprises a system for cooling the wire **W** which, preferably, provides for the at least partial immersion of the pulling capstans **2** and the dies **3** in a lubricating substance.

Advantageously, the aforementioned lubricating substance enables efficiently cooling the wire **W** even if it forms a small number of turns around each capstan **2** and, thus, the heat exchange surface between the wire and the capstans is small.

It is also clear that embodiments of the invention may provide for a different system for cooling the wire **W** with respect to the one described above.

Operatively, upon increasing the speed of the portion of the wire **W** comprised between the first capstan **2** and the die **3** immediately downstream, for example due to wear of the latter, the tension of the aforementioned portion of wire **W** tends to increase.

Increasing the tension of the wire **W** displaces the first pulley **5** towards the first capstan **2**, temporarily compensating the greater demand for the wire **W** downstream of the first capstan **2**.

Simultaneously, the sensor means detect the aforementioned displacement and command the increase of speed of the first capstan **2**, until the first pulley **5** reaches a stable position, a sign of successful adjustment of the speed of the first capstan **2** and the advancement speed of the wire **W**.

Clearly, the opposite of what has been described above occurs in case of reduction of the speed of the wire **W**.

The present invention also regards a method for drawing a metal wire **W** that provides for winding the wire **W** around a pulling capstan **2** and driving the latter in rotation so as to advance the wire **W** through a die **3** arranged upstream of the capstan.

A portion of the wire **W** at contact with the pulling capstan **2** is tensioned with a predefined tensioning force so as to generate - between the wire and the capstan - a friction sufficient to enable the transmission of the pulling force.

The method also provides for adjusting the rotation speed of the pulling capstan **2** in response to the speed change of the wire, increasing it upon the increase of the speed of the wire **W** and vice versa.

According to the method of the invention, the aforementioned tensioning force is increased upon detecting a difference between the advancement speed of the wire **W** exiting from the capstan and the peripheral speed of the latter.

The method described above enables adapting the tensioning force to any drawing condition, adjusting it to the minimum value compatible with absence of tangential sliding.

For this purpose, the method preferably provides for an operation for setting the tensioning force to a value suitable to produce a given initial sliding, so as to force the aforementioned adjustment.

Advantageously, the setting operation described above averts the possibility of setting a tensioning force higher than the strictly required one.

In the light of the above, it is clear that the drawing machine and the drawing method described above attain the objects of the invention.

In particular, the adjustment of the tensioning force of the wire in response to the change of drawing conditions enables maintaining the tension of the wire and, thus, the friction of the latter on each capstan, at the minimum value sufficient to guarantee the absence of tangential sliding.

The use of idle pulleys coupled to the capstans, having inclined axes with respect to the rotation axis of the latter, also enables eliminating the axial sliding of the wire.

CLAIMS

1) Machine (1) for drawing a metal wire (W) comprising:

- a succession of capstans (2) for pulling said wire (W) alternated with dies (3) and associated to means for driving the rotation thereof;
- elastically yieldable tensioning means (4) suitable to apply a tensioning force to a portion of said wire (W) arranged at contact with a first of said pulling capstans (2);
- means for controlling said driving means, suitable to adjust the rotation speed of said first pulling capstan (2) in response to a change in the geometric configuration of said tensioning means (4);

characterised in that it comprises:

- a sensor unit for measuring the peripheral speed of said first drawing capstan (2) and the advancement speed of said wire (W) in said portion;
- a system for adjusting said tensioning force, configured to increase said tensioning force upon detecting a difference between said advancement speed and said peripheral speed.

2) Machine (1) according to claim 1, **characterised in that** said tensioning means (4) comprise:

- a first idle pulley (5) configured to receive said wire (W) exiting from said first pulling capstan (2), rotatably associated to mobile support means (7) configured to enable the movement of said first pulley (5) in a displacement direction (Y) orthogonal to the rotation axis (X) of said first pulling capstan (2);
- a tensioner device (9) suitable to exert said tensioning force on said first pulley (5) according to said displacement direction (Y).

3) Machine (1) according to claim 2, **characterised in that** said mobile support means (7) comprise an oscillating arm (8) provided with a free end on which said first pulley (5) is fitted.

4) Machine (1) according to claim 3, **characterised in that** said tensioner device (9) comprises a pneumatic cylinder (10) associated to said oscillating arm (8).

5) Machine (1) according to any one of claims 2 to 4, **characterised in that** said first pulley (5) has a rotation axis inclined with respect to the rotation axis (X) of said first capstan (2).

6) Machine (1) according to claim 5, **characterised in that** it comprises a

second idle pulley (6) coaxial to said first pulley (5).

7) Machine (1) according to claim 6, **characterised in that** said second idle pulley (6) is rotatably released from said first pulley (5).

8) Machine (1) according to any one of claims 2 to 7, **characterised in that** said control means comprise sensor means for detecting a displacement of said first pulley (5) according to said displacement direction (Y) and they are configured to increase the speed of said first pulling capstan (2) when said displacement occurs in the direction opposite to said tensioning force and for reducing said speed when said first displacement occurs in the same direction as that of said tensioning force.

9) Machine (1) according to any one of claims 2 to 8, **characterised in that** said sensor unit comprises a detector for detecting the angular speed of said first pulley (5).

10) Machine (1) according to claim 9, **characterised in that** said detector comprises an encoder.

11) Machine (1) according to any one of the preceding claims, **characterised in that** said pulling capstans (2) and said dies (3) are at least partly submerged in a lubricating substance.

12) Machine (1) according to any one of the preceding claims, **characterised in that** it comprises a pilot capstan (11) arranged at the end of said succession of pulling capstans (2), associated to driving means for the rotation thereof at a pre-settable fixed speed.

13) Method for drawing a metal wire (W) comprising the following operations:

- winding said wire (W) around a pulling capstan (2);
- driving said pulling capstan (2) in rotation to advance said wire (W) through a die (3) arranged upstream of said pulling capstan (2);
- adjusting the rotation speed of said pulling capstan (2) in response to the change of speed of said wire (W);
- tensioning a portion of said wire (W) at contact with said drawing capstan (2) with a predefined tensioning force;

characterised in that it comprises the operation of increasing said tensioning force upon detecting a difference between said advancement speed of said wire (W) exiting from said pulling capstan (2) and the peripheral speed of said pulling capstan (2).

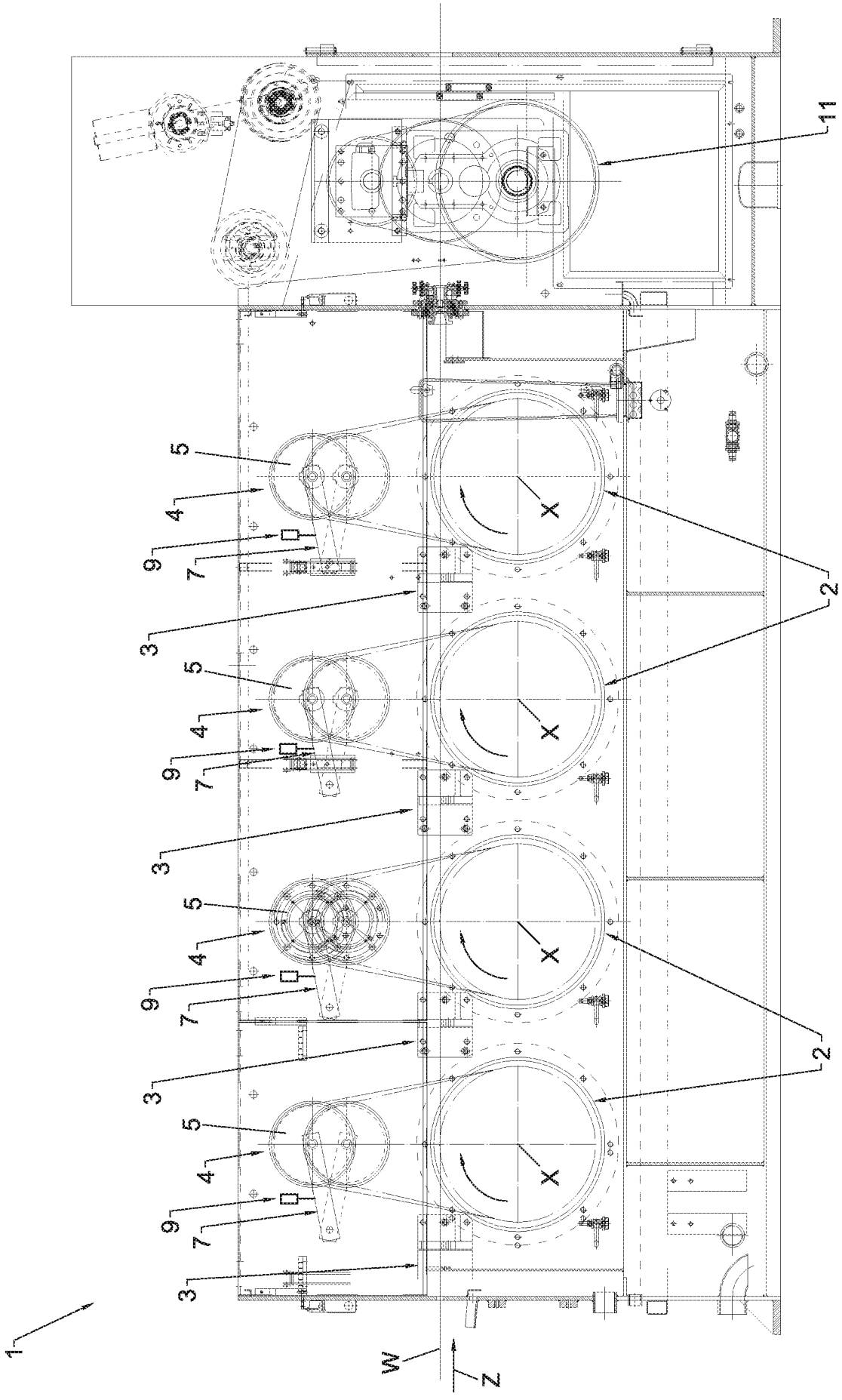

Fig.1

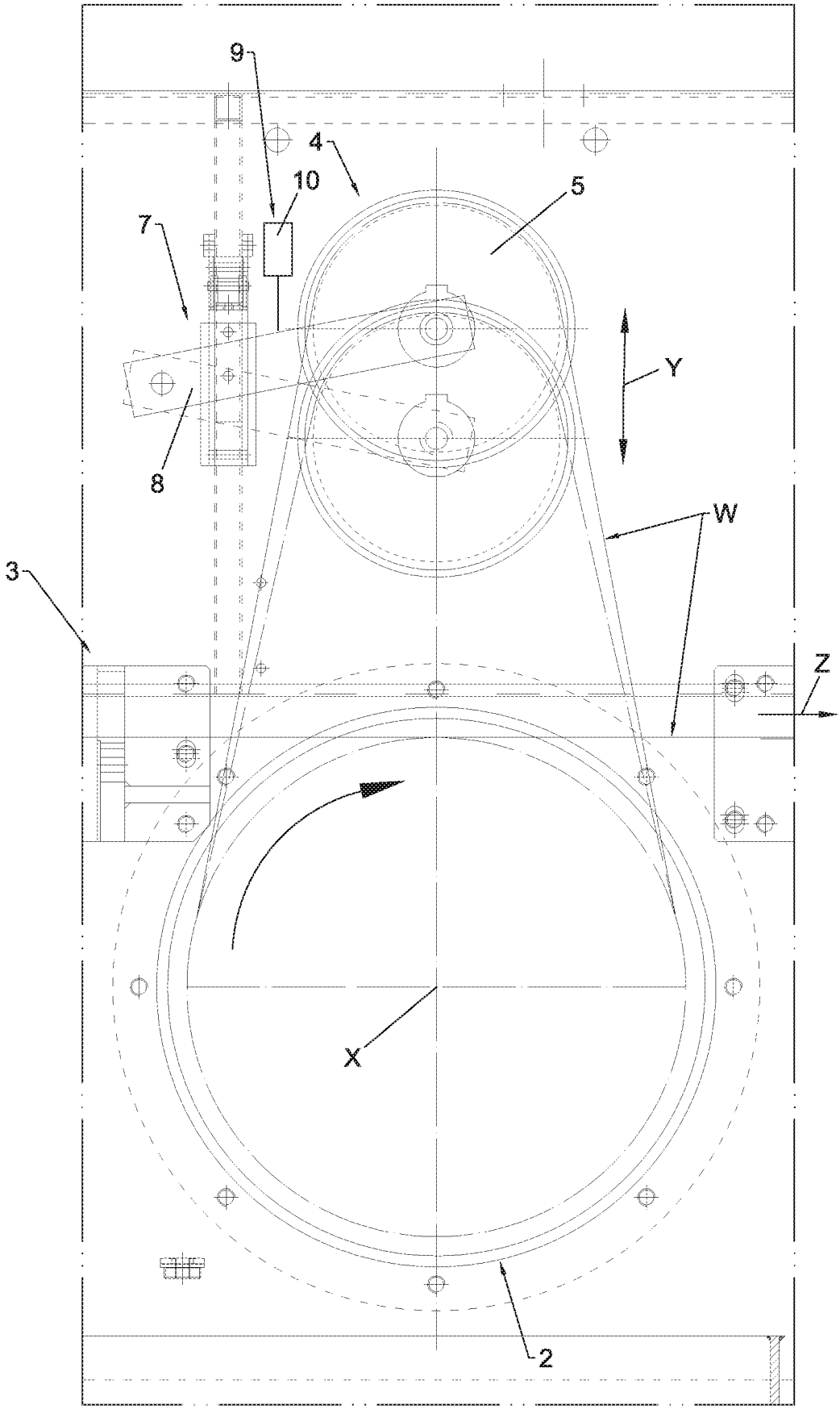

Fig.2

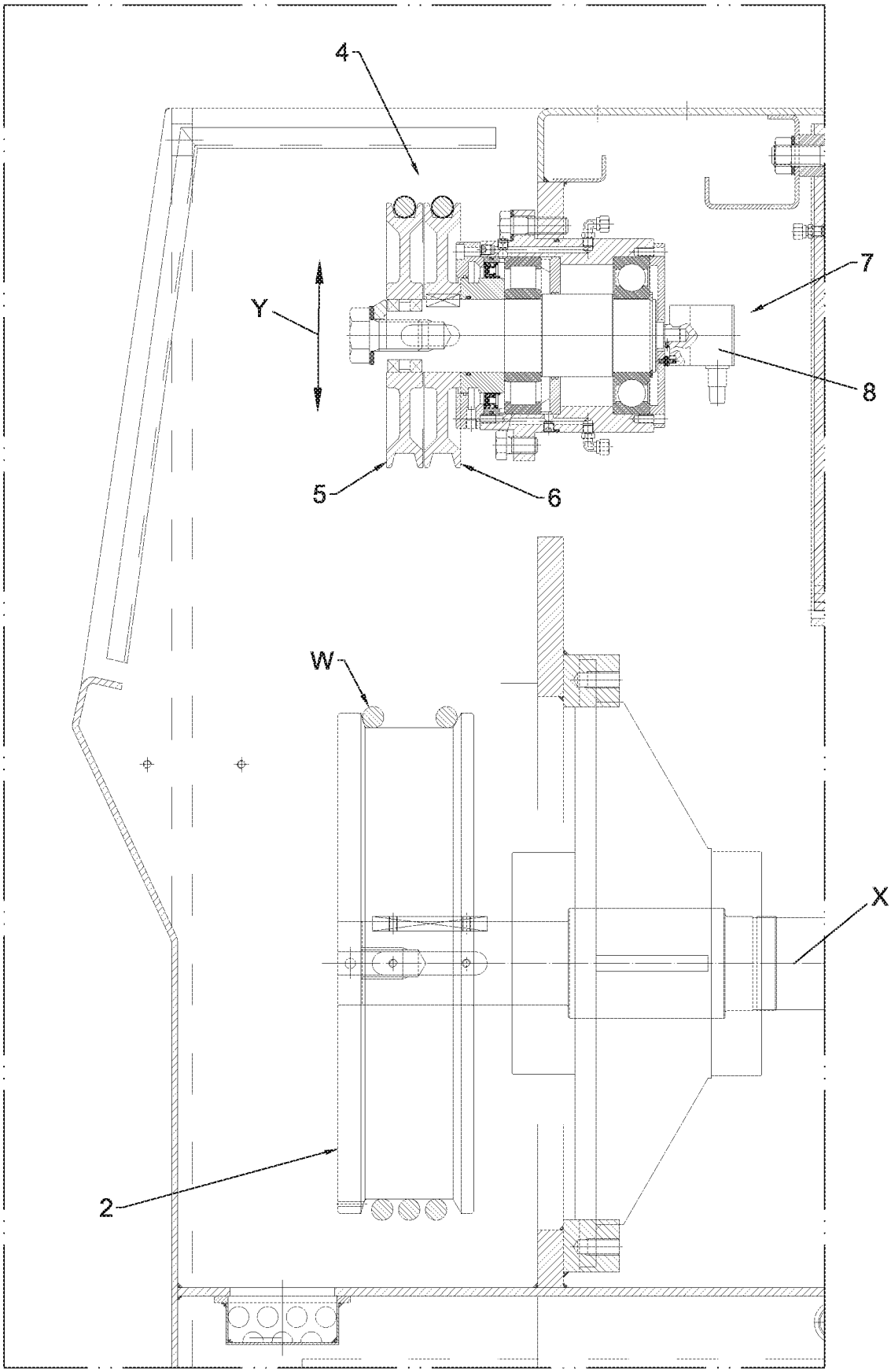

Fig.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/051035

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21C1/12
ADD. B21C1/08

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)
B21C

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA 712 892 A (NORTON CO LTD SIR JAMES FARMER) 6 July 1965 (1965-07-06) page 1, line 1 - line 20 page 2, line 8 - page 4, line 19; figures 1-4	1-4,8,13
A	GB 539 588 A (HAROLD JOHN LLOYD; SAMUEL HUGH RICHARDS) 17 September 1941 (1941-09-17) page 1, line 8 - line 106 page 2, line 104 - page 3, line 86; figures 1,3	1-3,8, 12,13
A	US 4 079 609 A (HODGSKISS BRIAN J) 21 March 1978 (1978-03-21) column 3, line 64 - column 4, line 43 column 5, line 1 - line 10; figure 1	1,2,8, 12,13

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[X] Further documents are listed in the continuation of Box C.

[X] 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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 2017	06/06/2017

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/051035

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 660 100 A (GERHARDI W) 6 July 1929 (1929-07-06) the whole document -----	1-3,8,13
A	EP 0 673 689 A1 (MECCANICA DI PRECISIONE SPA [IT]) 27 September 1995 (1995-09-27) column 1, line 34 - column 2, line 50; figures 1,2 -----	1,2,5,13

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2017/051035

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