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(54) Title: MASTERING OF TRIMMING KNIVES POSITION

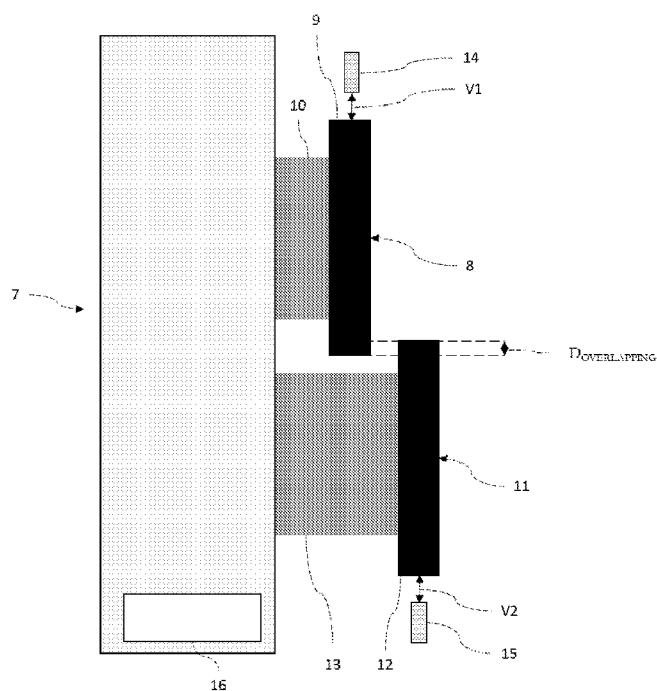


Figure 2

(57) Abstract: Trimming device for metallic sheets comprising : - an upper knife (9), comprising a central circular face (8) having a diameter D1 and a thickness T1, mounted on an upper shaft (10), - a lower knife (12), comprising a central circular face (11) having a diameter D2 and a thickness T2, mounted on a lower shaft (13), - wherein said upper knife (9) and said lower knife (12) are vertically shifted with an overlap ( $D_{OVERLAP}$ ) so as to define a shear of said metallic sheet and - wherein at least one of said upper or lower shaft (10, 13) is able to be moved vertically, - a first distance sensor (14), able to measure a vertical distance V1 to the upper end of said upper knife (9), - a second distance sensor (15), able to measure a vertical distance V2 to the lower end of said lower knife (12), - a computing means (16) able to compute said overlap.

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## MASTERING OF TRIMMING KNIVES POSITION

This invention relates to a trimming device, a trimming method and a method permitting to assess the wear of a trimming device.

5 After undergoing pickling operations in cold rolling lines or annealing treatment, a steel strip is generally trimmed. Such a trimming has several advantages. Firstly, it permits to achieve a desired width for a steel strip. Secondly, it guarantees the edge quality by removing irregular defects on the strip edges caused by upstream processes.

10 The side trimming is done by a pair of trimming knives, an upper one and a lower one, on each side of a steel strip. The knives have a thickness generally comprised between 20 and 40 mm. A pair of knives defines a shear having two major process parameters: a gap and an overlap. The gap is a horizontal distance between the two knives while the overlap is the vertical distance between the uppermost point of the lower knives and the lowermost point of the upper knife.

15 A trimming device treats various steel grades, from soft ones such as Interstitial-Free steel to hard ones such as AHSS steel. However, depending on the steel grade and format, the overlap and gap distances have to be tuned. For example, a too large overlap can lead to excessive forces on the trimming knives, a stress in the trimmed material or a speed difference between the trimming knives which all can result in more friction accelerating the wear of the trimming knives.

Overall, if the trimming is not properly controlled, it can negatively impact the quality of the strip edges, the line productivity, the trimming device lifespan and downstream processes.

20 The overlap and the gap are usually calibrated offline. However, it is desired to measure those distances online to control more efficiently the trimming process.

25 CN 102 489 772 discloses a system permitting to control online the overlap of a trimming device. It comprises, as illustrated in Figure 1, an upper trimming knife 1 mounted on an upper shaft 2, a lower trimming knife 3 mounted on a lower shaft 4, an upper shaft position detecting sensor 5 and a lower shaft detecting sensor 6 . The overlap is measured by using the position of the upper 2 and lower 4 shafts detected by the sensors (5 and 6).

The purpose of this invention is to precisely measure the overlap of two knives during the trimming of metallic sheets. A second goal of this invention is to correctly position the trimming knives during the trimming of metallic sheets and to detect the wear of the trimming device.

5 This is achieved by providing a trimming device according to any one of the claims 1 to 4. This is also achieved by providing trimming methods according to any one of the claims 5 and 9.

Other characteristics and advantages will become apparent from the following detailed description of the invention.

10 To illustrate the invention, various embodiment will be described, particularly with reference to the following figures:

Figure 1 illustrates a trimming device as known in the prior art.

Figure 2 illustrates an embodiment of a trimming device as disclosed in the present invention.

Figure 3 illustrates the impact of bent shafts on the measurement as known in the prior art.

15 Figure 4 illustrates a second embodiment of a trimming device as disclosed in the present invention.

As illustrated in Figure 2, the invention relates to a trimming device 7 for metallic sheets comprising:

- 20 - an upper knife 8, comprising a central circular face 9 having a diameter  $D1$  and a thickness  $T1$ , mounted on an upper shaft 10,
- a lower knife 11, comprising a central circular face 12 having a diameter  $D2$  and a thickness  $T2$ , mounted on a lower shaft 13,
- wherein said upper knife 8 and said lower knife 11 are vertically shifted with an overlap ( $D_{OVERLAP}$ ) so as to define a shear of said metallic sheet and
- 25 - wherein at least one of said upper 10 or lower 13 shaft is able to be moved vertically,
- a first distance sensor 14, able to measure a vertical distance  $V1$  to the upper end of said upper trimming knife,

- a second distance sensor 15, able to measure a vertical distance  $V_2$  to the lower end of said lower trimming knife,
- a computing means 16 able to compute said overlap.

5 The trimming device is able to trim metallic sheets having a thickness from 1 to 10 mm. The trimming device can be used at any step of the process. This trimming device is preferably downstream a pickling line or an annealing device.

As illustrated in Figure 2, the upper and lower trimming knives (8, 11) are disks mounted on a shaft in a way that the rotation of the shaft leads to the rotation of the trimming knives. For example,  
10 the trimming knives can be inserted on the shaft and then put under pressure by means of screws. In Figure 2, the means permitting to fasten the trimming knives to the shaft are not represented. The trimming knives are preferentially made of a material respecting the norm EN 1.2344 or EN 1.2343, with a diameter ( $D_1$ ,  $D_2$ ) from 300 to 500 mm and a thickness ( $T_1$ ,  $T_2$ ) from 20 to 60 mm.

The computing means is connected to the sensors and has access to the measured vertical  
15 distance  $V_1$  and  $V_2$ . The computing means has also access to the diameter of the first and second trimming knives.

The upper 8 and lower 11 trimming knives define a shear. The shear is usually defined by the distance between the lower end of the upper trimming knife and the upper end of the lower trimming knife, i.e. the areas in contact with the trimmed piece during the trimming. So, in Figure 2, the shear  
20 distance is between, the bottom right of the upper trimming knife and the upper left of the upper trimming knife. The vertical component of the shear defines the overlap ( $D_{OVERLAP}$ ) and the horizontal one defines the gap ( $D_{GAP}$ ).

The upper shaft 10 and/or the lower shaft 13 can be moved vertically permitting to set a desired overlap. The upper shaft and/or the lower shaft can be moved horizontally permitting to set  
25 a desired gap distance.

The position of the first sensor in relation to the second sensor is known. The first and second sensors are preferably fastened to the trimming device.

The first distance sensor 14 is placed above the upper knife 18 in order to measure a vertical distance to the upper end of said upper knife. The second distance sensor 15 is placed below the lower

knife 11 in order to measure a vertical distance to the lower end of said lower knife. It has been noticed by the inventors that such positionings are advantageous because a direct measure of the knife positions is possible without being subject to the shaft deformation. Whereas a measure of the knife position through the shaft position is not reliable because the shafts tend to be bent during the trimming leading to a vertical displacement of the shaft close to the trimming knives in comparison to the shaft close to the motor (at the opposite of the knives). This is illustrated in Figure 3, wherein the shafts (2', 4') are bent leading to a gap difference between the shafts for a position close to the trimming knives ( $D_{KNIVES}$ ) and one at the opposite ( $D_{MOTOR}$ ).

Consequently, the measure of the present invention is more reliable than the one of the prior art because it is not negatively impacted by the shaft bending.

Preferably, as illustrated in Figure 4, said trimming device 7, wherein :

- said upper knife and said lower knife are horizontally shifted to define a gap distance ( $D_{GAP}$ ),
  - at least one of said upper 10 or lower 13 shaft is able to be moved horizontally,
  - said computing means are able to compute said gap distance,
- said trimming device further comprising:
- a third distance sensor 17, able to measure a horizontal distance H1 to said upper knife,
  - a fourth distance sensor 18, able to measure a horizontal distance H2 to said lower knife.

The position of the third 17 sensor in relation to the fourth 18 sensor is known. The third and fourth sensors are preferably fastened to the trimming device.

The third distance sensor 17 is placed aside the upper knife 8 in order to measure a horizontal distance to said upper knife. The fourth distance sensor 18 is placed aside the lower knife 11 in order to measure a horizontal distance to said lower knife. During the trimming, two sides can be defined for each pair, composed of a lower and an upper knife, of knives: a product side and a shaft side. The product side being the side on which the product runs and the shaft side being the side on which the shafts are. Preferably, the third and fourth distance sensors are placed on the shaft side.

Preferably, said first, second, third and fourth distance sensors are inductive sensors.

Preferably, said first and second distance sensors are laser sensors because such sensors have a wider range of measurement than the inductive sensors, e.g. they can measure a larger variation of the overlap.

5 Preferably, said first shaft and said second shaft are both able to be moved vertically.

The invention also relates to a method of trimming metallic sheets, by a trimming device as previously described, comprising the steps of:

- 10
- measuring a first vertical distance,  $V1$ , between said first distance sensor 14 and said central circular face 9 of said upper knife 8,
  - measuring a second vertical distance,  $V2$ , between said second distance sensor 15 and said central circular face 12 of said lower knife 11,
  - computing an overlap,  $L_{MEASURED}$ , based on said first and second vertical distances, the diameters of said upper ( $D1$ ) and lower ( $D2$ ) knives and the position of said first distance

15 sensor relative to the position of said second distance sensor.

Preferably, the invention relates to a method of trimming steel sheets.

20 Preferably, in said method an overlap working range, from  $L_{MINIMUM}$  to  $L_{MAXIMUM}$ , is defined and said method comprises the steps of:

- comparing  $L_{MEASURED}$  to  $L_{MINIMUM}$  and  $L_{MAXIMUM}$ ,
- if  $L_{MEASURED}$  is smaller than  $L_{MINIMUM}$ , moving vertically at least one of said moveable shaft (10, 13) to set  $L_{MEASURED}$  at least equal to  $L_{MINIMUM}$ ,

25

- if  $L_{MEASURED}$  is greater than  $L_{MAXIMUM}$ , moving vertically at least one of said moveable shaft (10, 13) to set  $L_{MEASURED}$  at maximum to  $L_{MAXIMUM}$ .

$L_{MINIMUM}$  and  $L_{MAXIMUM}$  can be defined as a percentage of the thickness of the metallic sheet being trimmed.

30 Preferably, said overlap working range is from 4 to 25 percent of the thickness of said metallic sheet.

Preferably, the method also comprises the steps of:

- 5 - measuring a first horizontal distance, H1, between said third distance sensor (17) and said upper knife (8),
  - measuring a second horizontal distance, H2, between said fourth distance sensor (18) and said lower knife (11),
  - computing a gap distance,  $G_{\text{MEASURED}}$ , based on said third and fourth distances, the thickness of said upper (T1) and lower (T2) trimming knives and the position of said third distance sensor relative to the position of said fourth distance sensor.
- 10

Preferably, in said previously described method a gap working range, from  $G_{\text{MINIMUM}}$  to  $G_{\text{MAXIMUM}}$ , is defined and the method comprises the steps of :

- comparing  $G_{\text{MEASURED}}$  to  $G_{\text{MINIMUM}}$  and  $G_{\text{MAXIMUM}}$ ,
  - 15 - if  $G_{\text{MEASURED}}$  is smaller than  $G_{\text{MINIMUM}}$ , moving horizontally at least one of said moveable shaft to set  $G_{\text{MEASURED}}$  at least equal to  $G_{\text{MINIMUM}}$ ,
  - if  $G_{\text{MEASURED}}$  is greater than  $G_{\text{MAXIMUM}}$ , moving horizontally at least one of said moveable shaft to set  $G_{\text{MEASURED}}$  at maximum to  $G_{\text{MAXIMUM}}$ .
- 20

The invention also relates to a method for assessing the wear of a trimming device, as previously described, comprising the steps of :

- 25 - while said trimming knives are still, measuring an overlap,  $L_{\text{STILL}}$ , according to the previously described method,
  - measuring an overlap,  $L_{\text{ROTATING}}$ , between said two trimming knives being rotating, according to the previously described method,
  - comparing said two measurements,  $L_{\text{STILL}}$  and  $L_{\text{ROTATING}}$ ,
  - emitting an alert if the difference between  $L_{\text{STILL}}$  and  $L_{\text{ROTATING}}$  is greater than a predefined
- 30 threshold value  $L_{\text{DANGER}}$

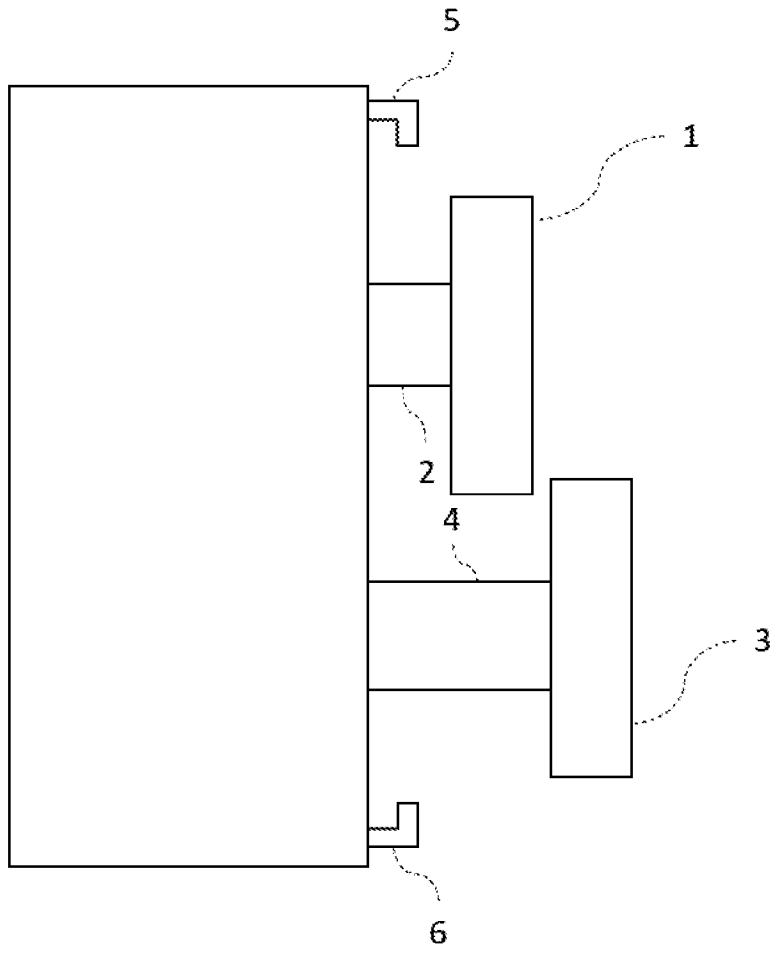
It has been discovered by the inventors that worn trimming devices tend to exhibit a “jump” of the overlap when the trimming life are set in motion or stopped, e.g. turned on or turned off. Displacement of from 10 to 40  $\mu\text{m}$  is noticeable. Apparently, those jumps are due to the wear of the bearings fastening the knives and mechanical clearance when the trimming device is on. Consequently, this  
5 jump cannot be assessed by off-line measurement nor by measurement of the knives position through the shaft.

## CLAIMS

1. A trimming device (7) for metallic sheets comprising:
  - an upper knife (8), comprising a central circular face (9) having a diameter  $D_1$  and a thickness  $T_1$ , mounted on an upper shaft (10),
  - a lower knife (11), comprising a central circular face (12) having a diameter  $D_2$  and a thickness  $T_2$ , mounted on a lower shaft (13),
  - wherein said upper knife and said lower knife are vertically shifted with an overlap ( $D_{OVERLAP}$ ) so as to define a shear of said metallic sheet and
  - wherein at least one of said upper (10) or lower (13) shaft is able to be moved vertically,
  - a first distance sensor (14), able to measure a vertical distance ( $V_1$ ) to the upper end of said upper knife,
  - a second distance sensor (15), able to measure a vertical distance ( $V_2$ ) to the lower end of said lower knife,
  - a computing means (16) able to compute said overlap.
2. A trimming device (7), according to claim 1, wherein :
  - said upper knife and said lower knife are horizontally shifted to define a gap distance ( $D_{GAP}$ ),
  - at least one of said upper (10) or lower (13) shaft is able to be moved horizontally,
  - said computing means are able to compute said gap distance;said trimming device further comprising:
  - a third distance sensor (17), able to measure a horizontal distance ( $H_1$ ) to said upper knife,
  - a fourth distance sensor (18), able to measure a horizontal distance ( $H_2$ ) to said lower knife;
3. A trimming device, according to claim 1 or 2, wherein said first, second, third and fourth distance sensors are inductive sensors.
4. A trimming device, according to any one of claims 1 to 3, wherein said first shaft and said second shaft are both able to be moved vertically.
5. A method of trimming metallic sheets by a trimming device according to any one of the claims 1 to 4, comprising the steps of:

- measuring a first vertical distance,  $V1$ , between said first distance sensor (14) and said central circular face (9) of said upper knife (8),
  - measuring a second vertical distance,  $V2$ , between said second distance sensor (15) and said central circular face (12) of said lower knife (11),
  - computing an overlap,  $L_{MEASURED}$ , based on said first and second vertical distances, the diameters of said upper (D1) and lower (D2) knives and the position of said first distance sensor relative to the position of said second distance sensor.
6. Method according to claim 5, wherein an overlap working range, from  $L_{MINIMUM}$  to  $L_{MAXIMUM}$ , is defined and wherein the method comprises the steps of :
- comparing  $L_{MEASURED}$  to  $L_{MINIMUM}$  and  $L_{MAXIMUM}$ ,
  - if  $L_{MEASURED}$  is smaller than  $L_{MINIMUM}$ , moving vertically at least one of said moveable shaft to set  $L_{MEASURED}$  at least equal to  $L_{MINIMUM}$ ,
  - if  $L_{MEASURED}$  is greater than  $L_{MAXIMUM}$ , moving vertically at least one of said moveable shaft to set  $L_{MEASURED}$  at maximum to  $L_{MAXIMUM}$ .
7. Method according to claim 5 or 6 comprising the steps of:
- measuring a first horizontal distance,  $H1$ , between said third distance sensor (17) and said upper knife (8),
  - measuring a second horizontal distance,  $H2$ , between said fourth distance sensor (18) and said lower knife (11),
  - computing a gap distance,  $G_{MEASURED}$ , based on said third and fourth distances, the thickness of said upper (T1) and lower (T2) trimming knives and the position of said third distance sensor relative to the position of said fourth distance sensor.
8. Method according to claim 7, wherein a gap working range, from  $G_{MINIMUM}$  to  $G_{MAXIMUM}$ , is defined and wherein the method comprises the steps of :
- comparing  $G_{MEASURED}$  to  $G_{MINIMUM}$  and  $G_{MAXIMUM}$ ,
  - if  $G_{MEASURED}$  is smaller than  $G_{MINIMUM}$ , moving horizontally at least one of said moveable shaft to set  $G_{MEASURED}$  at least equal to  $G_{MINIMUM}$ ,
  - if  $G_{MEASURED}$  is greater than  $G_{MAXIMUM}$ , moving horizontally at least one of said moveable shaft to set  $G_{MEASURED}$  at maximum to  $G_{MAXIMUM}$ .

9. Method for assessing the wear of a trimming device, according to any one of claims 1 to 4, comprising the steps of :
- while said trimming knives are still, measuring an overlap,  $L_{STILL}$ , according to claim 5,
  - measuring an overlap,  $L_{ROTATING}$ , between said two trimming knives being rotating, according to claim 5,
  - comparing said two measurements,  $L_{STILL}$  and  $L_{ROTATING}$ ,
  - emitting an alert if the difference between  $L_{STILL}$  and  $L_{ROTATING}$  is greater than a predefined threshold value  $L_{DANGER}$ .



**PRIOR ART**

Figure 1

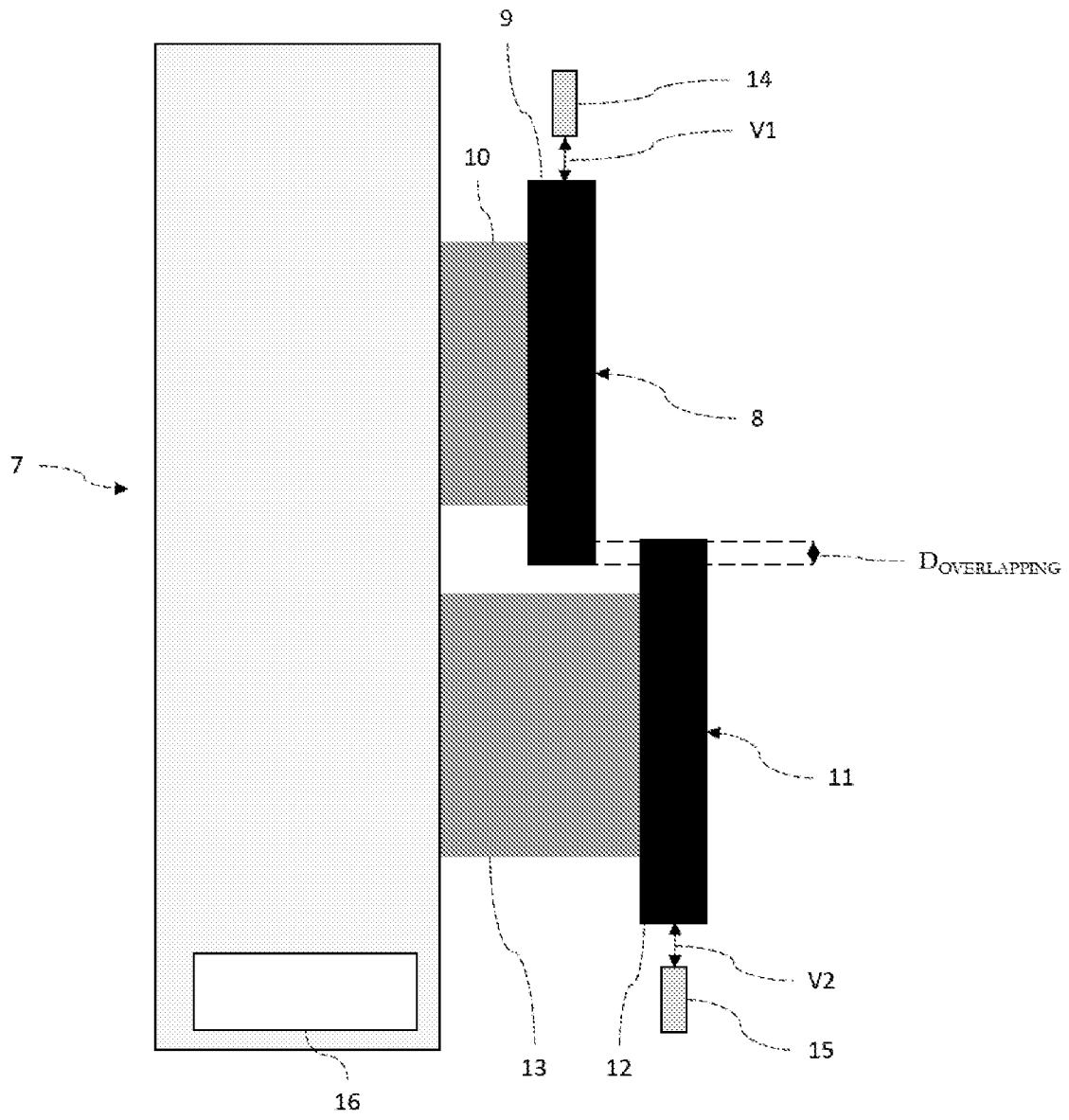
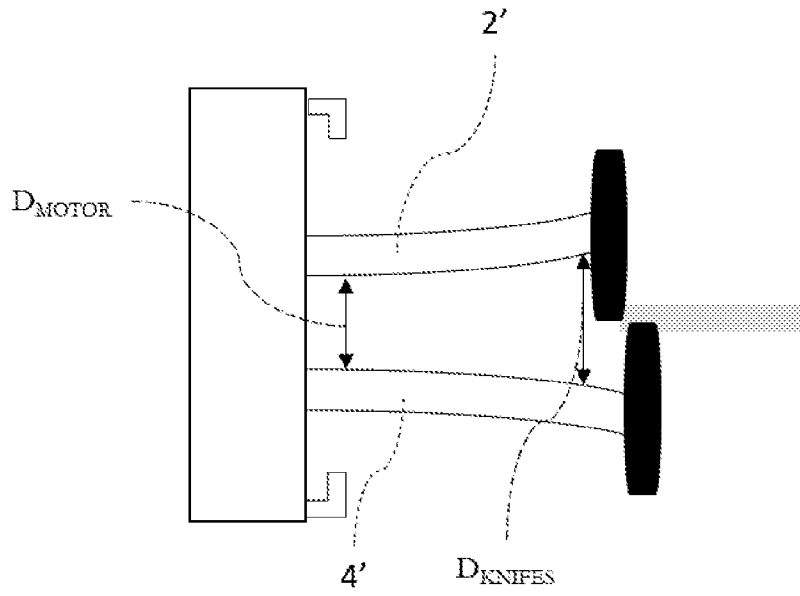


Figure 2



**PRIOR ART**

Figure 3

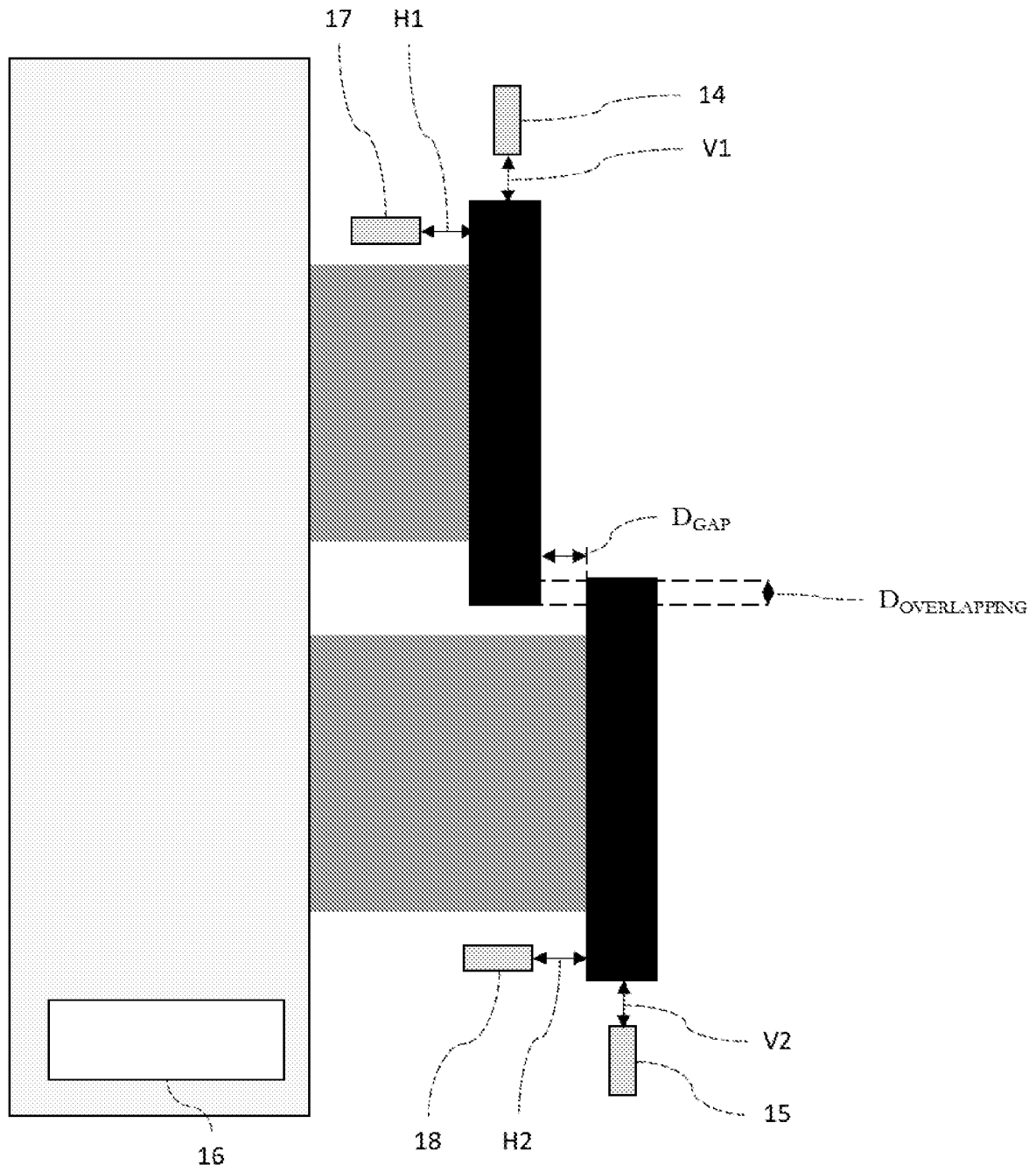


Figure 4

**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/IB2020/061933

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. B23D19/04 B23D35/00  
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)  
B23D

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.
X	JP 2002 096214 A (KAWASAKI STEEL CO) 2 April 2002 (2002-04-02) paragraph [0015]; figures the whole document	1-9
A	----- CN 102 489 772 A (CISDI ENG CO LTD) 13 June 2012 (2012-06-13) cited in the application claim 1 the whole document	4
A	----- CN 110 026 600 A (UNIV SICHUAN) 19 July 2019 (2019-07-19) the whole document	1,5-8
A	----- CN 111 468 775 A (CHINA NAT HEAVY MACH RES INST) 31 July 2020 (2020-07-31) the whole document	1,5,9
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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
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- "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 <b>1 September 2021</b>	Date of mailing of the international search report <b>17/09/2021</b>
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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 <b>Rabolini, Marco</b>
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2020/061933

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016/107249 A1 (CARTWRIGHT MICHAEL [GB] ET AL) 21 April 2016 (2016-04-21) paragraph [0014] - paragraph [0015]; figures paragraph [0037] the whole document -----	3

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2020/061933
---

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 2002096214	A	02-04-2002	NONE	
CN 102489772	A	13-06-2012	NONE	
CN 110026600	A	19-07-2019	NONE	
CN 111468775	A	31-07-2020	NONE	
US 2016107249	A1	21-04-2016	BR 112015029981 A2	25-07-2017
			CN 105408043 A	16-03-2016
			EP 3003623 A1	13-04-2016
			GB 2514774 A	10-12-2014
			JP 2016524548 A	18-08-2016
			KR 20160014723 A	11-02-2016
			RU 2015156476 A	14-07-2017
			US 2016107249 A1	21-04-2016
			WO 2014195071 A1	11-12-2014