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(54) Title: A PROCESS FOR LASER CUTTING A METAL PLATE

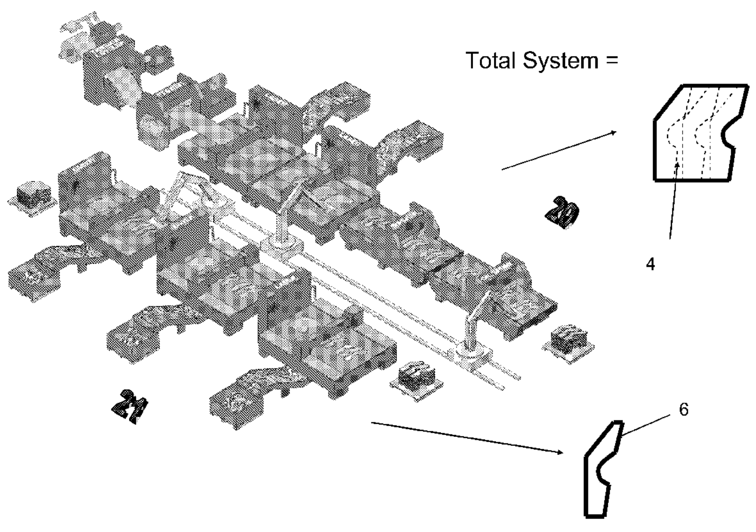

Figure 9

(57) Abstract: A process for laser cutting a metal plate, especially for laser blanking, comprising providing at least a laser cutting device, a metal plate to be cut from a metal coil, and at least a holding apparatus holding and maintaining the metal plate, and cutting said metal plate by means of at least a laser beam delivered by said at least one laser cutting device while said metal plate is held and maintained in position by said at least one holding apparatus. The metal plate is first cut by a first line comprising at least a first cutting machine, into at least one peripheral blank, and at least one peripheral blank is subsequently fed to at least a second line comprising at least a second cutting machine, to be cut into several smaller individual final blanks. The first line produces peripheral blanks faster than at least one second cutting machine of the second line can cut them into several smaller individual final blanks.

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A process for laser cutting a metal plate

The present invention relates to a process for laser cutting a metal plate comprising a first line with at least a first cutting machine for cutting said metal plate into at least one peripheral blank, and at least a second line comprising at least a second cutting machine for cutting the peripheral blank into several smaller individual final blanks.

Sheet metal blanking in production is still today processed with mechanical means of either shears or presses and blanking dies. These mechanical methods result in either large engineering scrap rates or large capital expenditures in dedicated tooling costs and in storage, transportation, maintenance and repair costs for these tools. They are ideal only when the number of varieties of parts to be cut is small, thus resulting in fewer tool change set-up downtimes.

However, in today's market where the number of models of vehicles for example is constantly increasing, the corresponding increase in number of dedicated tools makes mechanical processes more expensive and less adapted to lean and flexible manufacturing.

Hence, there is a need for a laser cutting process that would enable the cutting of blanks without requiring an expensive dedicated or part specific tooling and that would lead to improved productivity and/or an optimized production of blanks.

Preferably, such a laser cutting process, especially a laser blanking process, should be as flexible as possible, i.e. part changes can be done by changing a CNC software part program.

The problem to be solved is to improve laser cutting process, especially laser blanking process so as to overcome at least some of the prior art drawbacks.

The solution according to the present invention concerns a process for laser cutting a metal plate, especially a laser blanking process, comprising the steps of :

a) providing at least a laser cutting device,

b) providing a metal plate to be cut from a metal coil,

c) providing at least a holding apparatus holding and maintaining the metal plate,

d) cutting said metal plate by means of at least a laser beam delivered by said at least one laser cutting device while said metal plate is held and maintained in position by said at least one holding apparatus,

wherein in step d) :

i) the metal plate is first cut by a first line comprising at least a first cutting machine, into at least one peripheral blank, and

ii) at least one peripheral blank is subsequently fed to at least a second line comprising at least a second cutting machine, to be cut into several smaller individual final blanks, and wherein said first line produces peripheral blanks faster than at least one second cutting machine of the second line can cut them into several smaller individual final blanks.

Depending on the embodiment, the process of the present invention can comprise one or several of the following features:

- the first line produces peripheral blanks at least twice as fast as at least one second cutting machine of the second line can cut them into several smaller individual final blanks.

- in step c), the metal plate is vacuum suction held and maintained in position by said holding apparatus.

- in step c), the metal plate is vacuum suction held and maintained in position by one or several bridge rail modules of said holding apparatus, each comprising at least one suction cup module.

- the holding apparatus comprises a rigid support table frame having an X-axis and an Y-axis, and one or several bridge rail modules runs across the Y-axis of said table frame, each bridge rail module comprising at least one suction cup module.

- the holding apparatus comprises several bridge rail modules, each bridge rail module comprising several suction cup modules.

- each suction cup module is in fluid connection with at least a vacuum source.

- one or several bridge rail modules comprise at least one pin locator module.

- said bridge rail modules are parallel to each another.

- the apparatus further comprises a motion mechanism for moving a plate to be cut along the X-axis.

- the support table frame presents the surface of the substantially flat metal plate to be cut in a non-horizontal position during cutting.

- the support table frame presents the surface of the substantially flat metal plate to be cut in a vertical position during cutting.

- the support table frame is flat.

- at least a first cutting machine and at least a second cutting machine are chosen among laser cutting machines.

- at least a first cutting machine and at least a second cutting machine are chosen among fiber laser cutting machines, CO_2 laser cutting machines, disk laser cutting machines fiber and YAG laser cutting machines

- said first line produces peripheral blanks at a first speed that is between 3 and 12 times greater than a second speed of at least one second cutting machine of the second line that cut them into several smaller individual final blanks.

- the second line comprises several second cutting machines, each second cutting machines cutting peripheral blanks into several smaller individual final blanks.

- in step ii), at least one peripheral blank is stacked before being fed to said at least second line.

The present invention will be explained in details in the following description made in connection with the enclosed Figures.

One embodiment of the present invention concerns a process for laser cutting a metal plate, comprising the steps of providing at least a laser cutting device, a metal plate to be cut from a metal coil and at least a holding apparatus holding and maintaining the metal plate, and cutting said metal plate by means of at least a laser beam delivered by said at least one laser cutting device while said metal plate is held and maintained in position by said at least one holding apparatus.

During the cutting step, the metal plate is first cut by a first line comprising at least a first cutting machine, into at least one peripheral blank, and at least one peripheral blank is subsequently fed to at least a second line comprising at least a second cutting machine, to be cut into several smaller individual final blanks. The first line produces peripheral blanks faster than at least one second cutting machine of the second line can cut them into several smaller individual final blanks.

In order to yield the same throughput as mechanical cutting means, several laser cutting machines can be used in series or parallel configurations. The present invention describes a modular configuration with two stations and the means to enable the invention with minimum risk and maximum redundancy.

Figure 1 shows a traditional grid table for laser cutting operations. Grids 9 of toothed bridges for blank support, sitting across the table, are consumable structures and act only as bottom support for blank parts. These types of grids do not hold the material down and in place during cutting of the flat metal 10 along the cutting line 11, as represented in Figure 2, which can lead to cutting and/or quality issues when, for instance, the material's surface moves during cutting due to heat distortion or residual stress, or mechanical stress and/or thermal stress induced in the material during cutting. Furthermore, the teeth of the support-grid structure are sometimes on the cutting path of the laser beam which sometimes can yield cutting quality defects such as burr, dross, loss of cut, gouging, etc…

For these reasons, it is preferred, in the frame of the present invention, to use an engineered table as shown in Figures 3 and 4 for holding the pieces to be cut when carrying out the process according to the present invention.

More precisely, Figures 3 and 4 represent a top view of a metal plate 10, i.e. a metal coil, disposed on an engineered table to be used as the holding apparatus in an embodiment of the process of the present invention that comprises seven bridge rail modules 1 comprising a total of thirty two suction cups modules 2. Those of ordinary skill in the art will recognize that the number of bridge rail modules 1 can be greater than or lower than seven. The bridge rail modules 1 are preferably parallel one to the other, but each can also be designed with different orientations from the others, with respect to the Y direction. These bridge rail modules are fixed in position on the engineered table before the workpiece to be cut is brought on to the table. Once the workpiece is in a stationary position, the suction cup modules are activated to provide sufficient suction to hold down the material in place during cutting.

Figures 2, 3 and 4 show an example of a continuous coil feed presenting a workpiece progression above the engineered table. The workpiece is stopped periodically at the end of each progression.

In Figure 3, the bridge rail modules of the engineered table are shown in position immediately before the start of a new cut, whereas Figure 4 shows the same immediately after the end of a new cut line 11 and cut positioning holes 3. To enable such workpiece feed and stop periodic motion, a coil retardation loop can be put in place similar to that which is common in continuous coil die-blanking operations. The laser cut has been made in the flat metal-plate 10 (coil) between two successive bridge rail modules 1. Furthermore, two reference locator holes 3 have been also cut through the metal plate 10 forming the blank.

Figure 5 shows the peripheral blank 4 obtained after the laser cutting operation of Figure 4. This peripheral blank 4 has been laser cut at its ends along desired cutting lines 11, 11’. Lines 11’ and 11 have been obtained during two successive cuts, respectively, as illustrated in Figures 3 and 4, and explained above. The peripheral blank 4 further comprises the two reference locator holes 3. Those of ordinary skill in the art will recognize that the number of reference locator holes 3 can differ from 2.

Instead of a traditional grid of consumable toothed bar bridge, it is preferred, in the frame of one embodiment of the process of the present invention, to have a heavy duty universal flexible engineered table that not only provides the minimum material support necessary for a laser-cutting machine even if not optionally equipped with a height sensor closed-loop profiling, but also means for holding the material in place during cutting. The frame of the table should be of heavy duty construction. It should have X-axis guides along at least one X-axis side. In addition, it should be able to sustain direct or reflected laser irradiation without suffering from excessive heat distortion. If it is so wished, the bridge rail modules can be oriented parallel to or within an orientation angle from either the X or Y axis direction. In addition, these bridge rail modules do not have to be parallel to one another.

Such an engineered table can be comprised of many needed bridge rail modules 1 running across its Y-axis (parallel to the Y-axis or otherwise). These bridge rail modules 1 are slidable or movable along the X-axis rails of the table frame to allow for positioning anywhere along the X-axis of the table. Each bridge rail module 1 can be removed from the table for cleaning and/or maintenance and set-up. These bridge rail modules 1 are heavy duty rigid structures that should be designed as narrow as possible so that detached scrap parts could possibly fall through and be collected by a scrap conveyor underneath the table. If necessary, the part program may add additional cut sequences, to cut the engineering scrap into smaller pieces that can easily fall through the grid of bridge rail modules for evacuation and collection. These modules 1 may also include channels for an optional water cooling system. Optionally, engineered scrap pieces that do not fall through the grid of bridge rail modules can be evacuated and collected through different pre-engineered means.

Each bridge rail module 1 comprises heavy duty suction cup modules 2 and location pin modules 5 that are adjustable along the bridge rail. As many suction cups 1 and location pin modules 5 as needed can be used as along as they can spatially fit in a given bridge rail module 1.

The engineered table frame, bridge rail modules 1 and suction cup modules 2 have adequate machined surfaces that can be flat or not in order to provide local part support and also have suction which provides the equivalent of clamping tension to hold the material in place, i.e. the metal plate 10 to be cut, including providing tension in spaces between suction cup modules 2. The support surfaces of these modules 2 also serve as the reference height surface for the blanks 4 that rest on them. The support surfaces can be elevated with respect to the surface of the bridge rail module, or alternatively could be designed to be flush even with it.

Figures 6 and 7 show another embodiment of a holding apparatus useable for carrying out a process according to the present invention, wherein some of the bridge rail modules 1 comprise pin location modules 5 that are used for detecting/locating the reference locator holes 3 that have been pierced through the metal plate 10 forming the blank 4 as explained above.

Figures 5 and 6 show the peripheral blank 4 detached from the coil-feed station and before it is further cut into a multitude of smaller blank pieces, whereas Figure 7 shows five of these smaller blank pieces 6 after they have been cut in blank 4.

These suction cups 2 and pin location modules 5 are located strategically as a function of the nesting and of the part program path of the laser head. The path 12 of the cutting focusing head should preferably never go across a suction cup module 2 when the laser beam is on; however it can go across a bridge rail module. This eliminates the parts from tipping over without falling and also the parts from sticking out as a collision object on the path of the cutting head. It also avoids material moving from its position induced by heat input thermal displacements or residual stress spring back which could lead to parts being cut out of dimensional accuracy tolerances.

These suction cups 2 and pin locator modules 5 should preferably be easy to change for cleaning, maintenance or repair purposes. The whole table is rigid and can be leveled at installation so that all suction cup modules 2 surfaces are at the same reference height surface on which the workpiece rests during cutting. Small height changes are acceptable on the work envelope as long as they do not scratch the workpiece, nor permanently deform it, and as long as the slope of height difference does not exceed a threshold beyond which cutting performance variations become out of control across the work envelope.

As illustrated in Figure 8A, all elements of the suction cup modules are machined to present a leveled reference surface of the suction cup upon which the workpiece rests under the suction hold down. These elements can be circular, square or any appropriate and adequate shape and have a width Lc. Quick disconnects for compressed gas or air feed and return are an option.

The suction cup modules 2 are in fluid connection with at least a vacuum source, such as a vacuum pump, a Venturi type suction device or any other vacuum device able to create an under-pressure, i.e. a pressure less than the pressure of the surrounding atmosphere (< 1 atm), and to thus obtain a suction effect in the suction cup modules 2 allowing a firm holding of the piece to be cut.

As illustrated in Figure 8B, each bridge rail module 1 must be rigid as it will serve as a reference height surface. The bridge rail module 1 must also be heavy duty and easy to clean for purposes of maintenance. The width Lc of the suction cup module 2 reference surface can be either smaller than or larger than the width (or diameter if cylindrical) Lb of the bridge rail module. On an engineered table, suction cup modules 2 can have different sizes and shapes but should be set-up such that all present adequate reference surface position(s) upon which the blank rests. While, in most cases, the engineered table presents the workpiece in a horizontal position, during cutting, alternatively, the present invention includes set-ups in which the engineered table can present the workpiece surface in a non-horizontal position or even a vertical position during laser cutting.

Figure 9 represents an embodiment of a high speed laser blanking installation that can be equipped with the holding apparatus for carrying out the process of the present invention.

As one can see, the installation comprises several lines 20, 21 among which is a first line or coil-fed station for cutting and detaching the peripheral blanks 4, and a second line or blank-fed station for cutting and detaching the final individual parts or blank pieces 6 obtained from further cutting of the peripheral blanks obtained with the first line 20.

The metal plate (coil) is first cut by a first cutting machine of a first production line, into peripheral blanks 4, and then the peripheral blanks are subsequently fed to one or several second cutting machines of at least a second production line, to be cut into several smaller individual final blanks 6. Preferably, several second cutting machines are used and work in parallel.

These cutting machines are laser cutting machines, such as fiber laser cutting machines, CO_2 laser cutting machines, disk laser cutting machines fiber and YAG laser cutting machines.

According to the process of the invention, the first line, i.e. the coil-fed station 20, produces peripheral blanks faster than at least one cutting machine of the second line, i.e. the blank-fed station 21.

Indeed, each laser machine of the coil-fed station 20 generally has a cycle time per final part shorter than even press die-blanking. Therefore, for a line balancing cycle time point of view, one does not need two laser machines at the coil-fed station 20. However, it would allow redundancy during downtime for set-up, maintenance and repair of the laser machines. However, it is recommended to use at least two laser machines at the blank-fed station 21.

In other words, the workpiece is fed from a metal coil to be first cut by a first line composed of at least one laser cutting machine into at least one peripheral blank 4 and subsequently the peripheral blank is fed to a second line composed of at least another laser cutting machine to be cut into several smaller individual final blanks 6, with the proviso that the cutting and production speed of the first line producing the peripheral blanks 4 is much greater than the cutting and production speed of any machine of the second line producing the final individual blanks 6, preferably at least two times greater, and more preferably from 3 to 12 times greater.

For instance, the laser machine from the first line producing can produce a peripheral blank in 4 seconds, whereas the peripheral blank thus obtained is further cut into several final pieces in at least 8 seconds by any laser cutting machine of the second line. For these reason, the number of laser cutting machines of the second line is greater and proportional to the number of cutting machines of the first line. For example, if the first line is equipped with only 1 laser cutting machine thereby producing a peripheral blank 4 in 5 sec and if any laser cutting device of the second line needs 15 seconds for further cutting peripheral blank 4, then for improving or optimizing productivity, it is advocated to use at least 2 and ideally 3 laser cutting devices in the second line needs that work in parallel so as to obtain either a continuous working process or at least a process with a minimum of peripheral blank stacking.

The first line produces peripheral blanks faster than one cutting machine of the second line can cut them into several smaller individual final blanks. Preferably, the first line produces peripheral blanks faster than one cutting machine of the second line can cut them into several smaller individual final blanks. Thus, it is preferable to have at least two laser cutting machines in the blank-fed station.

Preferably, each laser machine needs to utilize a maximized “beam-on” value adding time, i.e., the material handling must wait for the laser cutting and not the other way around.

For the blank-fed station, the laser cutting machines preferably have dual tables, i.e., one side laser cuts while the other side is being loaded / unloaded.

The coil-fed station detaches peripheral blank contours but, if it is laser-cutting, it can make additional cuts, preferably without detaching any offal. This enables balancing the length of cutting between coil-fed and blank-fed stations.

Cutting per each progression of the coil generally takes several seconds, typically 3 to 4 sec., thus enabling ample time for material handling to evacuate or stack the detached peripheral blank contour.

Of course, as explained above, during the cutting operations, the peripheral blank 4 or the final individual part pieces 6 to be cut are firmly held by means of an (or several) apparatus equipped with suction modules 2 arranged on bridge rail modules 1 that preferably further also comprise location pin modules 5, especially when used in the blank-fed station 21.

By designing with this concept, the coil-fed station preferably does not generate detached offal, and therefore is not potentially hampered or slowed down by the time needed to evacuate offal. The coil support system during cutting is then simplified for the laser machines of the coil-fed station.

The installation further comprises a motion mechanism for moving a plate to be cut along the X-axis. Such kind of motion mechanism is well-known in the art.

Further, the installation also can comprise other well-known elements used for laser cutting, such as one or several:

- laser generator for generating a laser beam, like a fiber laser generator,
- laser cutting head that is used for cutting the metal plates,
- gas source, such as a gas conduit and/or a gas cylinder or storage vessel, for containing and feeding an assist gas or gas mixture to the laser head that is used for assisting said laser beam during cutting,

- device for moving the laser cutting head with respect to the workpiece so as to operate a cutting along the desired trajectory(ies),
- a control device, such as a CNC or similar, for piloting the laser head, the production cycles, etc…
- etc…

Of course, several peripheral blanks can also be cut in the same time in the workpiece by means of several laser cutting heads working in parallel.

CLAIMS

1. A process for laser cutting a metal plate, comprising

a) providing at least a laser cutting device,

b) providing a metal plate to be cut from a metal coil,

c) providing at least a holding apparatus holding and maintaining the metal plate,

d) cutting said metal plate by means of at least a laser beam delivered by said at least one laser cutting device while said metal plate is held and maintained in position by said at least one holding apparatus,

wherein in step d) :

i) the metal plate is first cut by a first line comprising at least a first cutting machine, into at least one peripheral blank, and

ii) at least one peripheral blank is subsequently fed to at least a second line comprising at least a second cutting machine, to be cut into several smaller individual final blanks,

and wherein said first line produces peripheral blanks faster than at least one second cutting machine of the second line can cut them into several smaller individual final blanks.

2. Process according to Claim 1, characterized in that said first line produces peripheral blanks at least twice as fast as at least one second cutting machine of the second line can cut them into several smaller individual final blanks.

3. Process according to Claim 1 or 2, characterized in that in step c), the metal plate is vacuum suction held and maintained in position by said holding apparatus.

4. Process according to any one of the preceding Claims, characterized in that in step c), the metal plate is vacuum suction held and maintained in position by one or several bridge rail modules of said holding apparatus, each comprising at least one suction cup module.

5. Process according to any one of the preceding Claims, characterized in that the holding apparatus comprises a rigid support table frame having an X-axis and an Y-axis, and one or several bridge rail modules runs across the Y-axis of said table frame, each bridge rail module comprising at least one suction cup module.

6. Process according to any one of the preceding Claims, characterized in that the holding apparatus comprises several bridge rail modules, each bridge rail module comprising several suction cup modules.

7. Process according to any one of the preceding Claims, characterized in that each suction cup module is in fluid connection with at least a vacuum source.

8. Process according to any one of the preceding Claims, characterized in that one or several bridge rail modules comprise at least one pin locator module.

9. Process according to any one of the preceding Claims, characterized in that said bridge rail modules are parallel to each another.

10. Process according to any one of the preceding Claims, characterized in that the apparatus further comprises a motion mechanism for moving a plate to be cut along the X-axis.

11. Process according to any one of the preceding Claims, characterized in that at least a first cutting machine and at least a second cutting machine are chosen among laser cutting machines.

12. Process according to any one of the preceding Claims, characterized in that at least a first cutting machine and at least a second cutting machine are chosen among fiber laser cutting machines, CO_2 laser cutting machines, disk laser cutting machines fiber and YAG laser cutting machines

13. Process according to any one of the preceding Claims, characterized in that said first line produces peripheral blanks at a first speed that is between 3 and 12 times greater than a second speed of at least one second cutting machine of the second line that cut them into several smaller individual final blanks.

14. Process according to any one of the preceding Claims, characterized in that the second line comprises several second cutting machines, each second cutting machines cutting peripheral blanks into several smaller individual final blanks.

15. Process according to any one of the preceding Claims, characterized in that, in step ii), at least one peripheral blank is stacked before being fed to said at least second line.

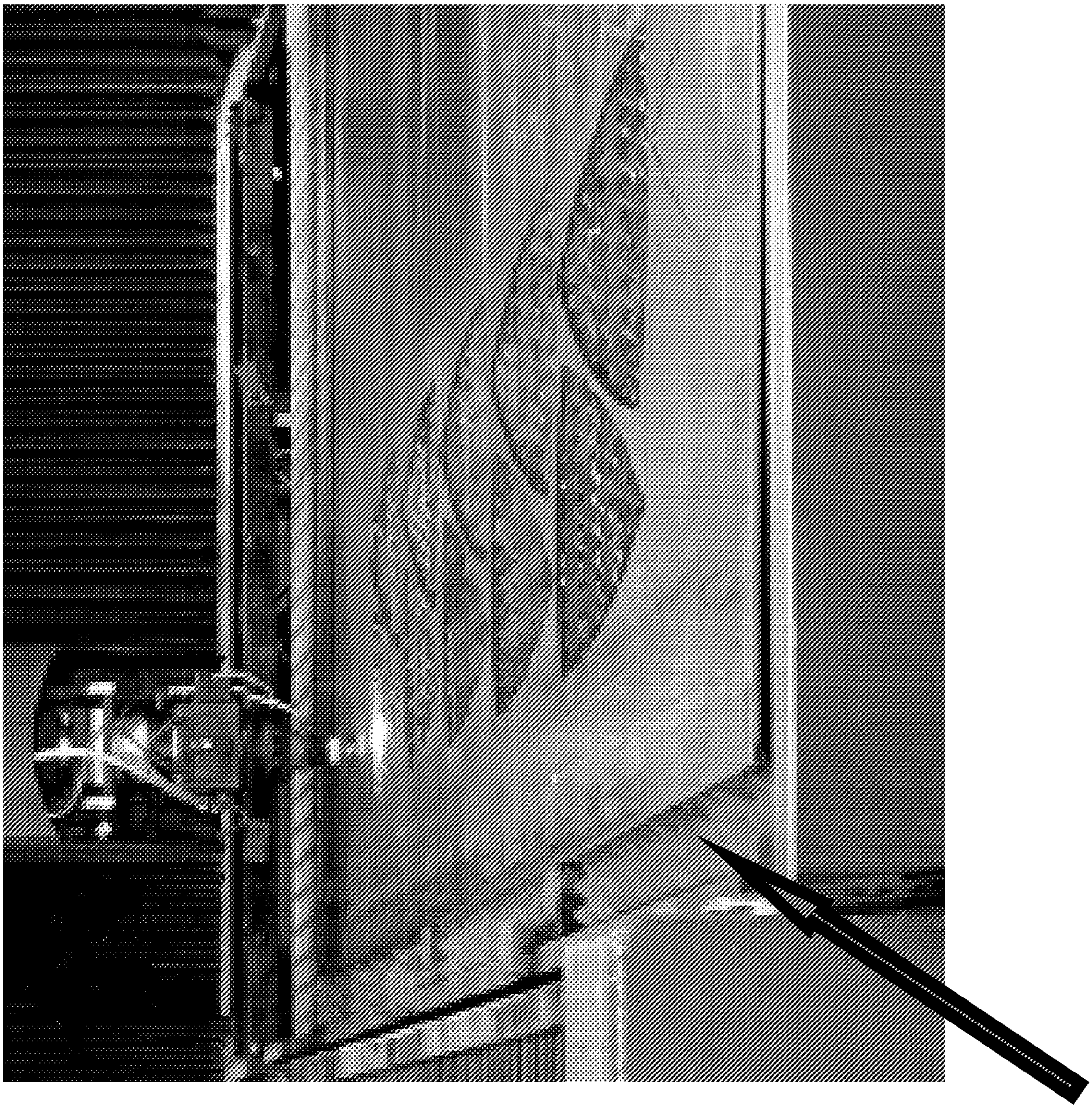

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Figure 1

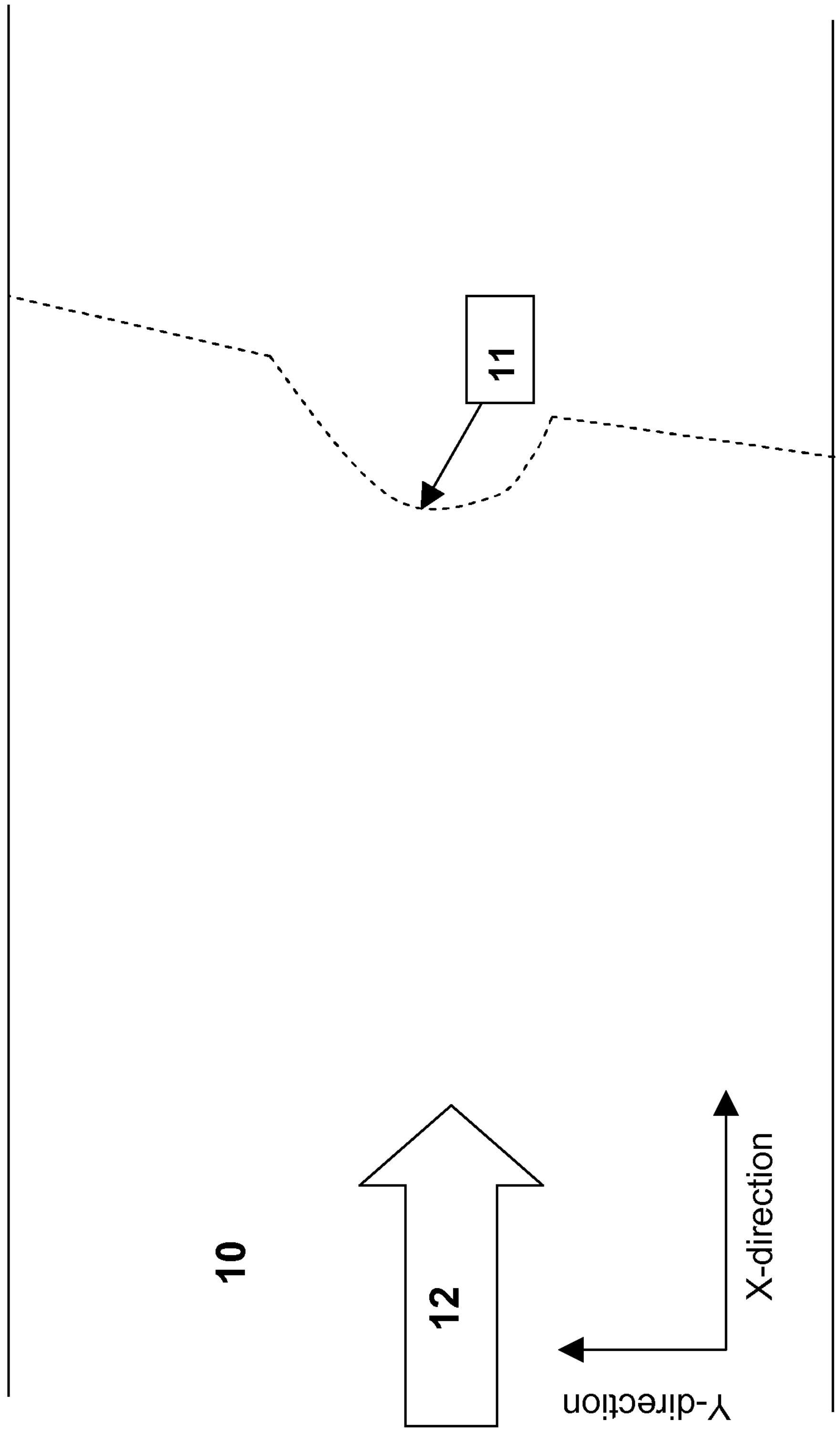


Figure 2

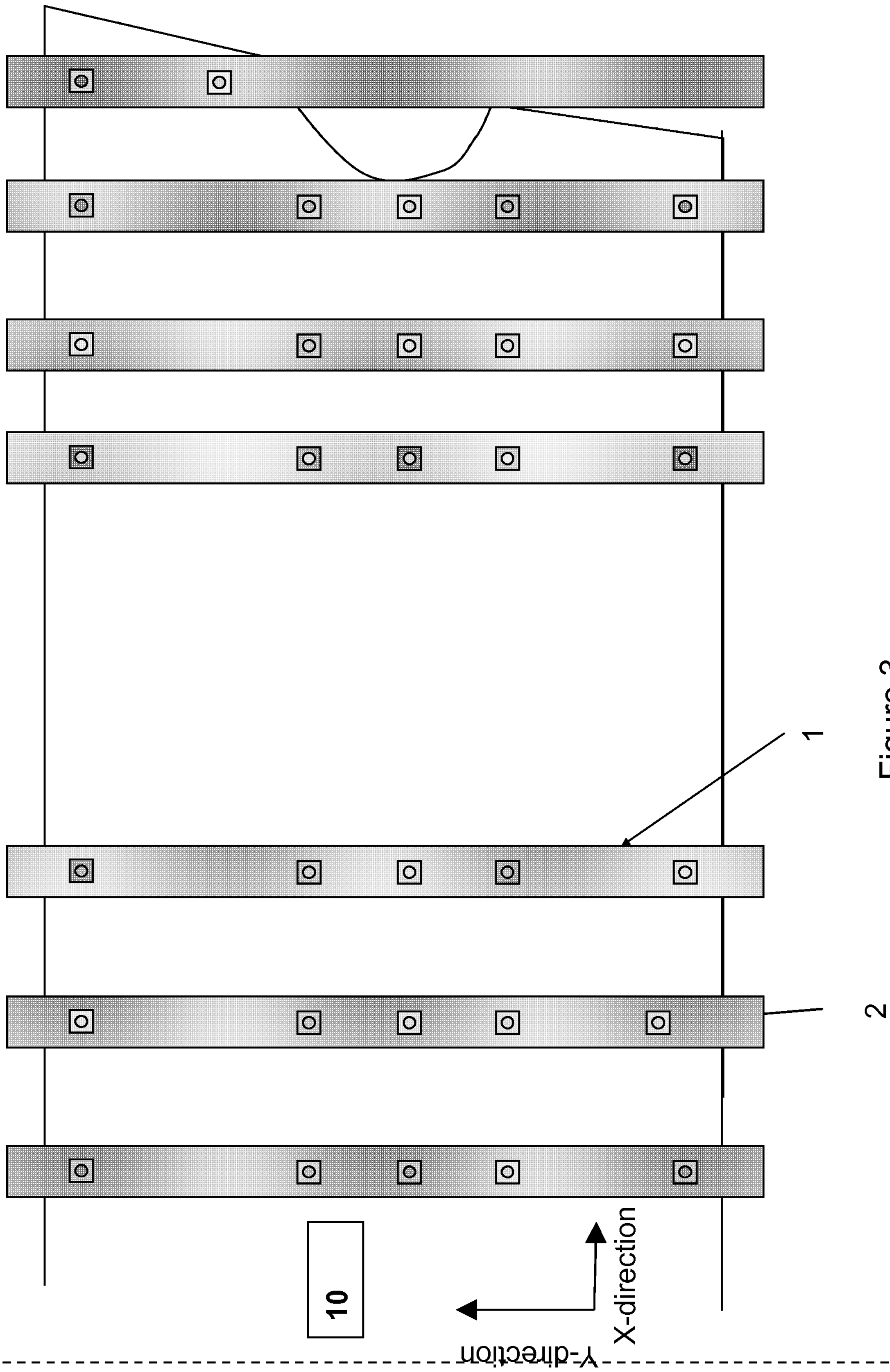


Figure 3

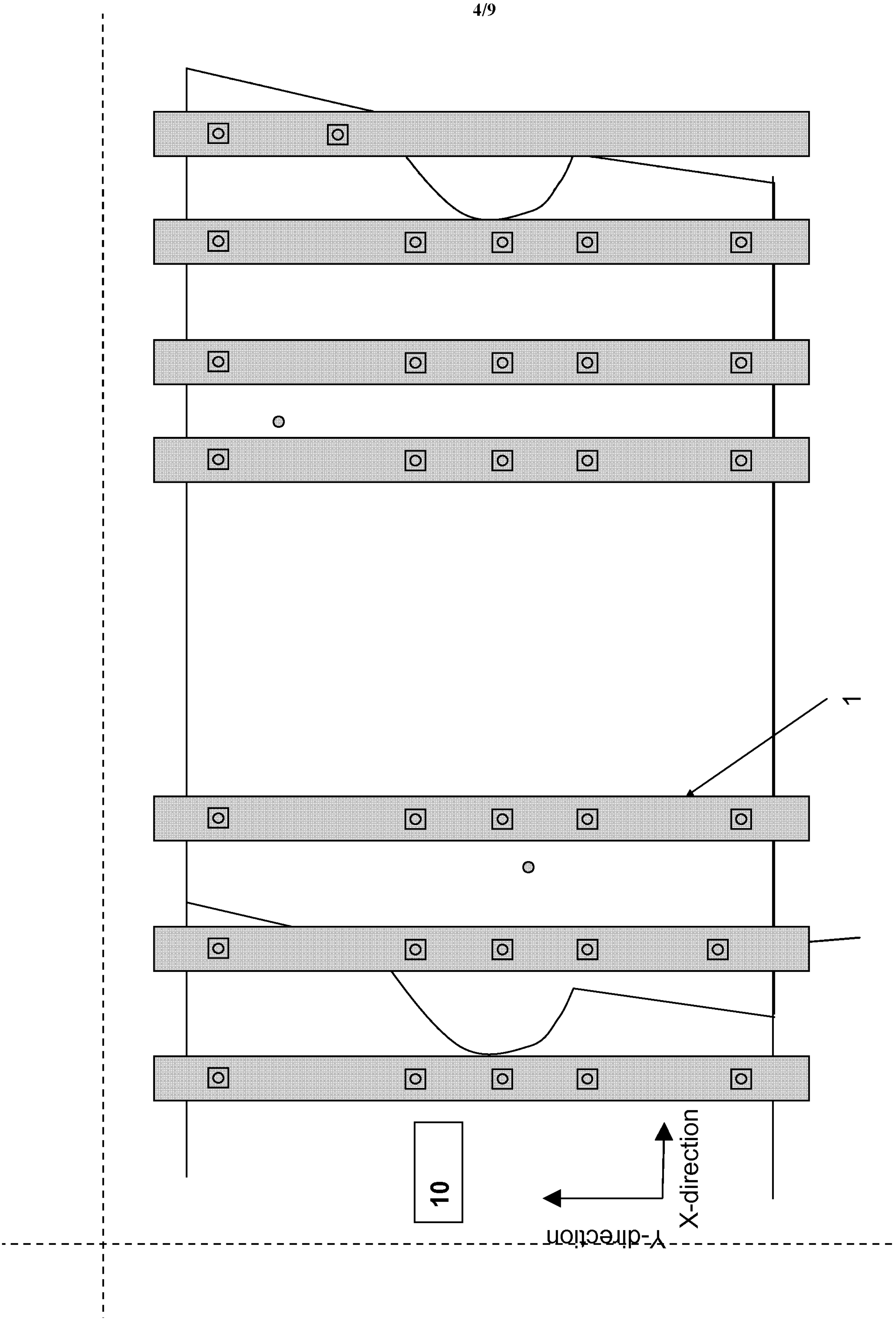


Figure 4

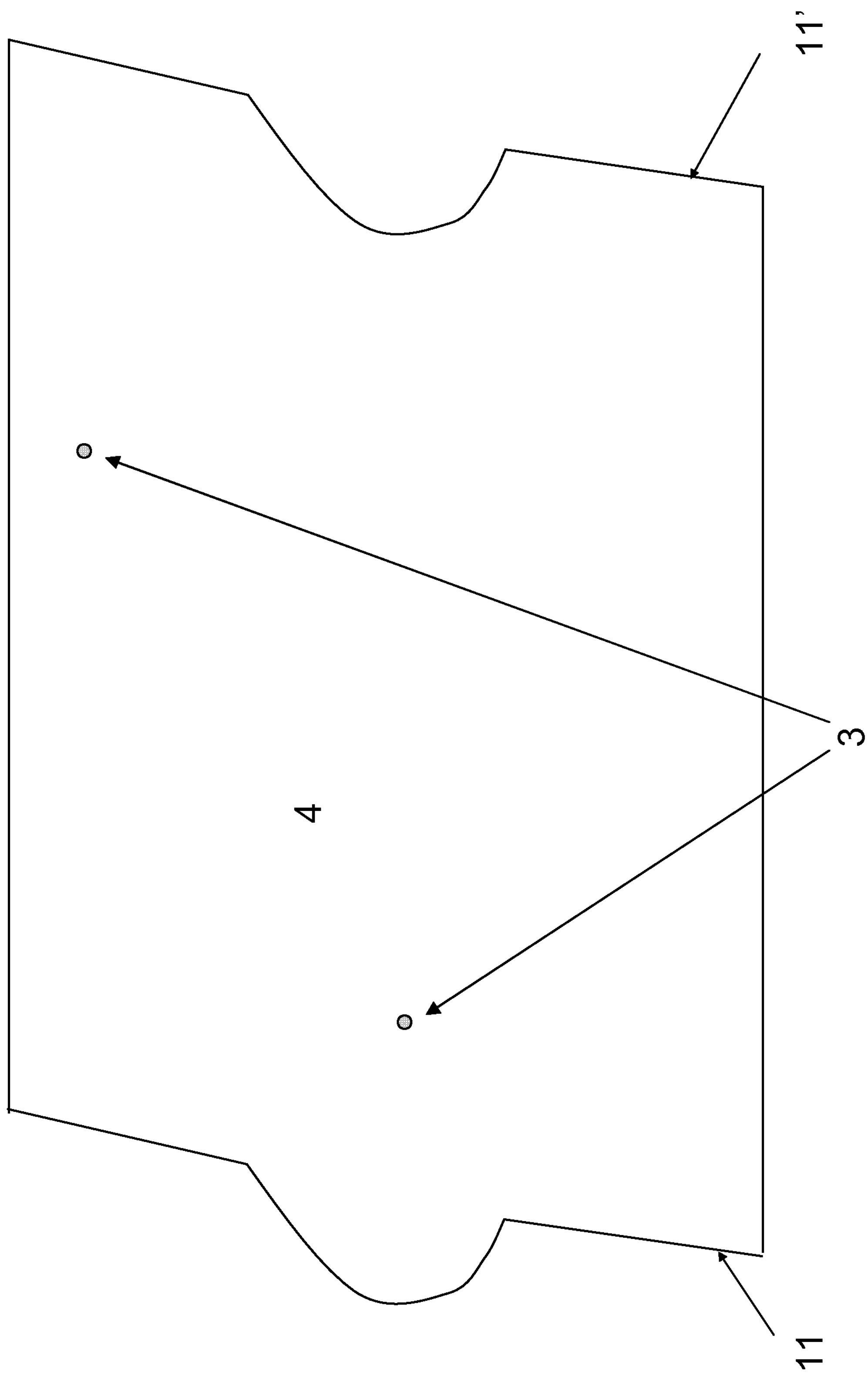


Figure 5

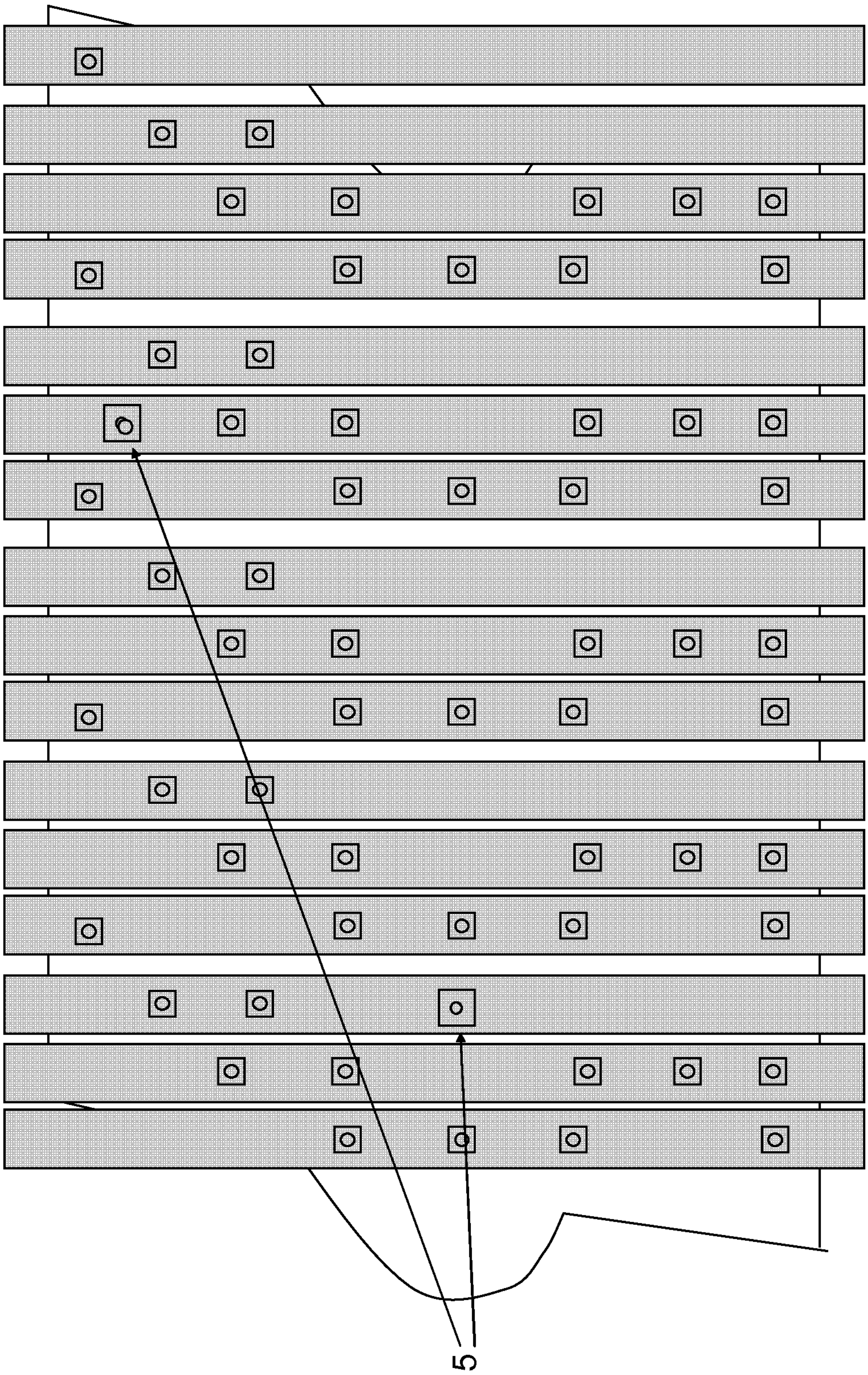


Figure 6

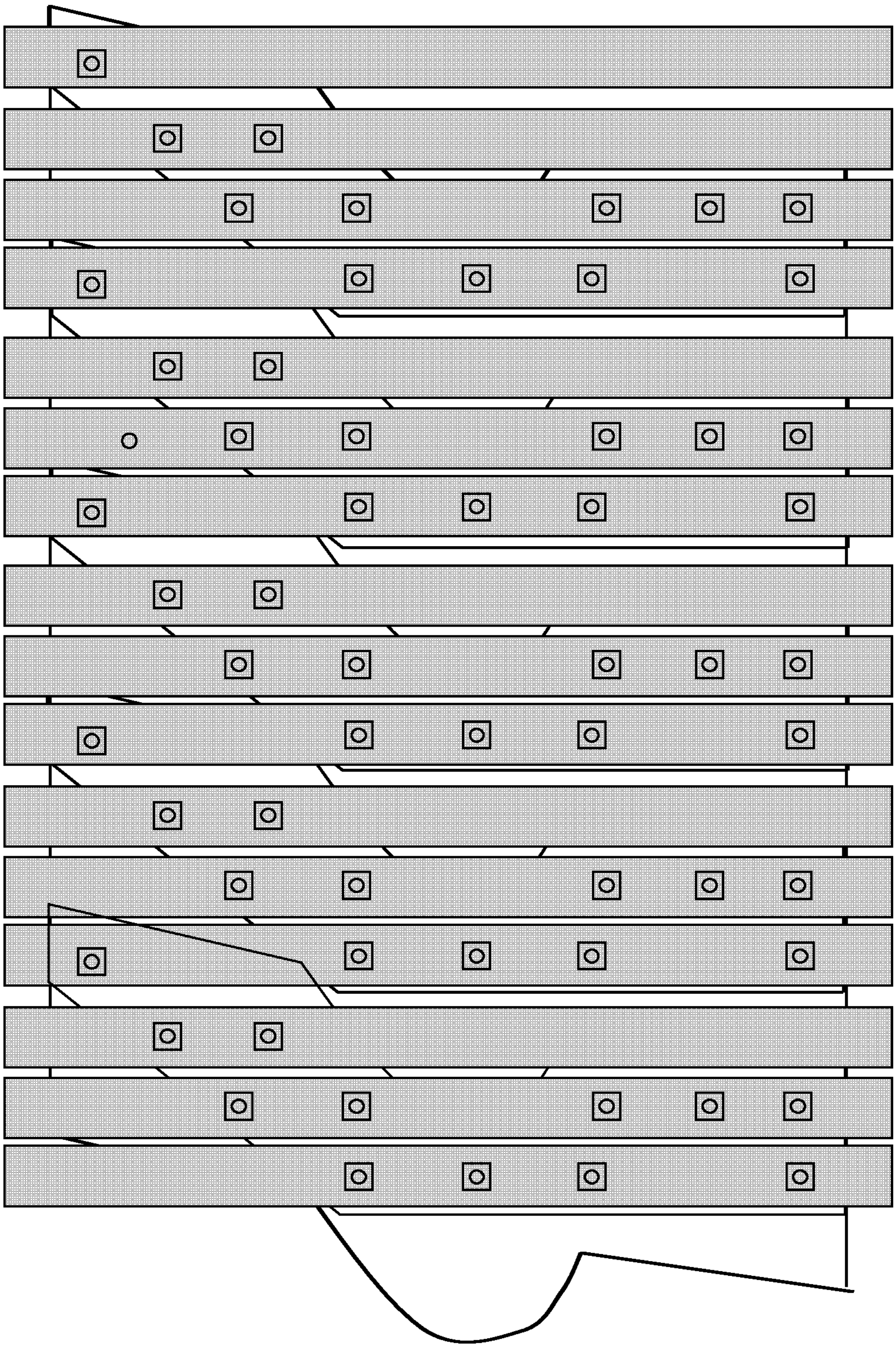


Figure 7

Figure 8

FIGURE 8B

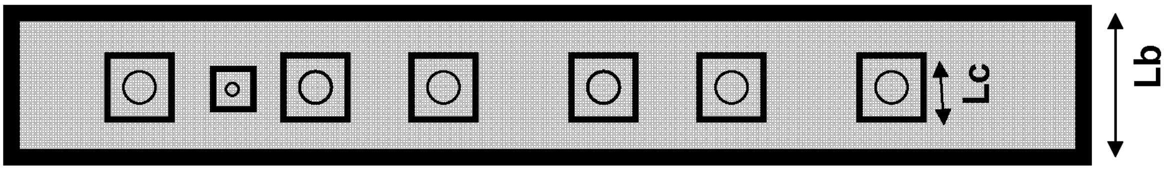
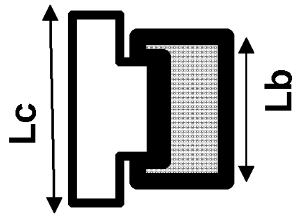


FIGURE 8A



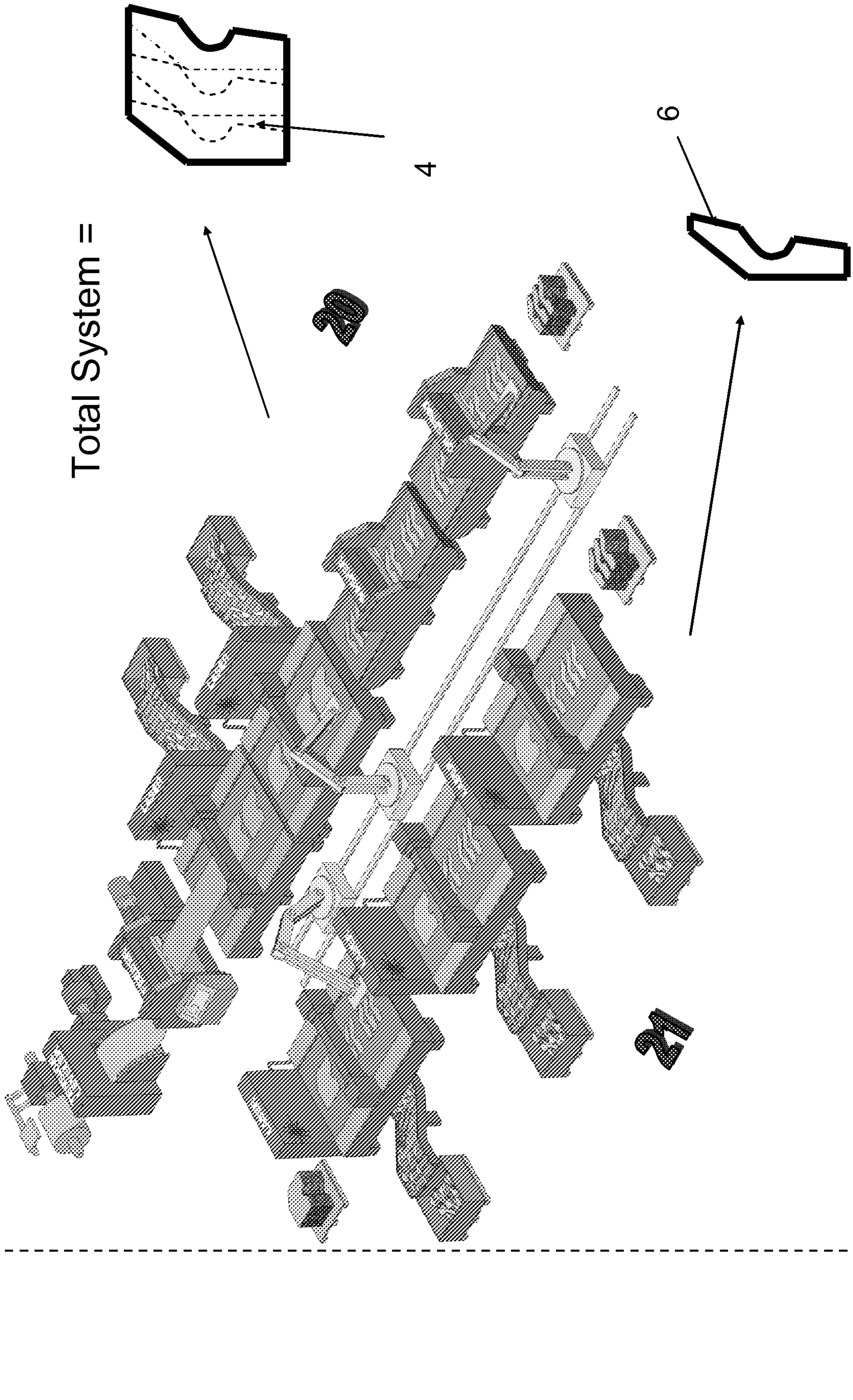


Figure 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/064815

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K26/08 B23K26/38 B23K37/04

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)
B23K

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 practical, 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.
Y	US 6 666 063 B2 (PICK GERHARD [DE] ET AL) 23 December 2003 (2003-12-23) figures 8-14	1-15
Y	EP 1 002 595 A2 (SCHULER PRESSEN GMBH & CO [DE]) 24 May 2000 (2000-05-24) paragraph [0019]	1-15
Y	EP 1 238 746 A2 (THYSSENKRUPP STAHL AG [DE]) 11 September 2002 (2002-09-11) paragraphs [0035], [0045]; figure 1	3-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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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
US 6666063 B2	23-12-2003	DE 10019368 A1	31-10-2001
		JP 2001321866 A	20-11-2001
		US 2002005056 A1	17-01-2002
EP 1002595 A2	24-05-2000	DE 19853366 A1	25-05-2000
		US 6710291 B1	23-03-2004
EP 1238746 A2	11-09-2002	DE 10111662 A1	26-09-2002