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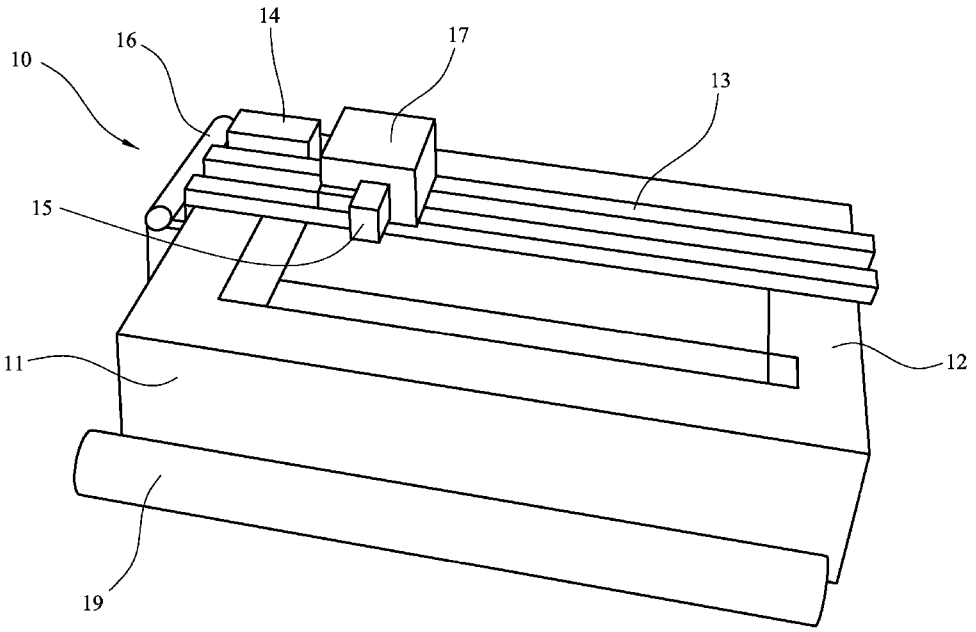

Figure 1

(57) Abstract: A laser cutting machine comprises a table (11) having a cutting surface (12) on which, in use, a material to be cut is located; a gantry (13) which extends across at least part of the width of the cutting surface; a laser source (14); and a laser scanner (15); wherein, in use, the laser source is static and the laser scanner is mounted and displaceable along the gantry; whereby the laser scanner deflects the laser produced by the laser source towards the cutting surface (12).

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Laser Cutters and Laser Cutting Systems

Field of the Invention

The invention relates generally to the field of cutting of textiles with applications in composite materials. The invention has particular relevance in the field of laser cutters and laser cutting systems.

Background to the Invention

The closest prior art known to the applicant are their own laser cutters for use in cutting composite materials such as textiles, construction materials and panels for vehicles. These known laser cutters and laser cutting systems typically comprise a table and gantry on which a laser is mounted and moved, and means for loading and unloading the material to be cut, such as a series of rollers. Laser cutters may also comprise one or more rotary or fixed blades to aid in the cutting process.

In this field there are constraints on space, time and cost of handling and cutting a material. The amount of space is defined by the typically large table and gantry on which a laser source is moved in use. The location and movement of the laser source on the gantry also affects the required time because the laser source can only be moved at a particular speed. A laser source is also typically only able to move across part of the length and width of a piece of material. These factors contribute to a higher cost of cutting a material.

There is also a need to unite printing and cutting processes where these are typically carried out separately by completely separate machines in existing systems. A conventional approach to cutting a material is to print marks and lines on a piece of material to be cut and arrange a camera in association with a laser for cutting the material. The marks and lines on the piece of material can be followed by the laser cutter to produce a cut piece of material that has a correct final shape. An example of this is disclosed in WO 94/23886. WO 94/2386 describes a laser cutter which has a laser mounted on a fixed frame for producing a static laser beam, and a mobile reflecting and focusing means which is mounted

on and moveable laterally, to and fro along a fixed rail, or gantry, along the direction of the laser beam. The beam is intercepted by the mobile reflecting and focusing means and deflected downwardly onto the material to be cut. The laser cutter uses an optical sensor, or camera, to scan the shape or pattern printed on the material and then cuts the material in the desired cutting path. During cutting, the material is movable back-and-forth longitudinally, using a bi-directional material feed means. By simultaneously controlling the movement of the material, and the perpendicular movement of the focusing means, any desired shape may be cut.

There is a real need to reduce the amount of time and space taken by a laser cutter whilst maintaining, and hopefully improving, the quality of the laser cutting process.

It is an object of the current invention to provide an improved laser cutter and laser cutting system.

Summary of the Invention

In a first, broad independent aspect the invention provides a laser cutting machine comprising a table having a cutting surface on which, in use, a material to be cut is located; a gantry which extends across at least part of the width of the cutting surface; a laser source; and a laser scanner; wherein, in use, the laser source is static and the laser scanner is mounted and displaceable along the gantry; whereby the laser scanner deflects the laser produced by the laser source towards the cutting surface.

Advantageously, the laser scanner (laser galvanometer or laser galvo) changes the angle of deflection of the laser produced by the laser source. Transverse motion of the laser scanner along the gantry (X axis) allows the whole width of the material to be covered. The laser beam can also be deflected by the laser scanner, to move the laser beam in the Y axis, which allows the laser scanner to move the laser beam longitudinally, as well as laterally across the table.

The table may additionally comprise a conveyor for advancing the material along

the length of the cutting surface. Incremental movement of the piece of material along the length of the cutting surface beneath the gantry allows a material of any length and width to be processed. For example, the laser cutting machine may be configured to incrementally cut in a cutting 'window' approximately 100mm wide at each pass.

As the skilled person knows, printed material generated by a conventional printer is typically advanced from the printer in increments, such as 50mm increments. The cutter described here can rapidly cut the material in increments of, for example, up to 100mm which will enable the laser cutter to advantageously directly cut the material output from a printer.

The laser source itself is advantageously not displaceable along the gantry but is instead static in use. This allows for high acceleration and speed of the laser scanner across the width of a piece of material. Such high speeds are not possible in existing apparatus, where a large laser source is carried on the gantry. A larger spot size is also typical where a laser source is transported along the gantry. Because the laser source is static in use and it is only the laser scanner that is displaced along the framework of the gantry, the gantry and the rest of the laser cutting machine can be minimised in size. In a field where space and time is typically restricted by the large size of a laser cutting machine and slow speed of a gantry carrying a laser source, the invention allows more machines and more material to be processed in a given period. The amount of energy required to move the laser scanner is also reduced compared to the energy required to move a heavier laser source along the gantry. Running costs are thus minimised. The configuration of the laser cutting machine allows the laser scanner to move from left to right across the whole width of material and incremental movement of the piece of material allows a material of any length and width to be processed.

In a subsidiary aspect, the laser scanner, or laser galvo, comprises a plurality of mirrors which deflect the laser produced by the laser source towards the cutting surface. A plurality of mirrors, preferably small mirrors, in the laser scanner enable a large deflection of the laser beam so large areas of material of any length and width can be covered. The mirrors of the laser scanner also minimise the spot size of the laser beam to cut material with maximum efficacy.

In a subsidiary aspect, at least one of said mirrors is adjustable within the laser scanner to change the angle of deflection of the laser produced by the laser source. Adjusting at least one of the mirrors allows the angle of deflection of the laser to be modified to improve cutting performance. Providing a static laser source allows rapid movement of the laser scanner and the mirrors mounted within the laser scanner.

In a subsidiary aspect, the plurality of mirrors are each plane mirrors.

In a subsidiary aspect, the laser scanner comprises a collimator. The collimator maintains a spot size over the entire scan width of the laser scanner so that effective and accurate cutting of material can be achieved.

In a subsidiary aspect, the laser scanner is configured to deflect a laser with a spot size of $1/e^2$.

In a further subsidiary aspect, the laser beam produced by the laser source is deflected by the laser scanner in three dimensions. Deflection of the laser beam by the laser scanner in three dimensions allows fast processing and cutting of large pieces of material. More specifically, whilst the gantry enables the laser scanner to move across the width of the cutting surface, i.e. left to right across a piece of material, deflection of the laser beam in three dimensions allows cutting across a larger area of material over a shorter period of time.

In a further subsidiary aspect, the distance between the laser scanner and the cutting surface is between 350mm and 450mm. A distance of 350mm to 450mm between the laser scanner and the cutting surface allows a shorter focal length lens to be used to minimise spot size of the laser beam. This configuration improves the accuracy and speed of cutting.

In a further subsidiary aspect, the distance between the laser scanner and the cutting surface is approximately 400mm. Because the distance between the laser scanner and the cutting surface is around 400mm, a shorter focal length lens can be used which minimises the spot size of the laser scanner for accurate cutting,

whilst the transverse motion of the laser scanner along the gantry allows the full width of a material to be straightforwardly and effectively covered.

In a further subsidiary aspect, the table comprises a conveyor for conveying a material, preferably, incrementally, along the length of the cutting surface. This configuration is particularly advantageous because the speed with which material is processed is improved. Also, minimal manual work from an operator is required so that multiple machines can be run by a single operator.

In a further subsidiary aspect, in use, the laser scanner moves at substantially 90 degrees to the cutting surface. Operating at 90 degrees to the cutting surface improves the efficacy and stability of the laser scanner.

In a further subsidiary aspect, the laser scanner is configured to move at a speed of at least 1.5 meters per second along the gantry. Configuring the laser scanner to move at a speed of at least 1.5 meters per second increases the amount of material which can be processed in a given period of time. This would not be possible, or would at least be more consumptive of time and cost, at lower speeds.

In a further subsidiary aspect, the machine further comprises an extractor for removing fumes created by the laser scanner at the cutting surface. The extractor removes all smoke and fumes from the cut area. Preferably, extraction is carried out from both above and below the cut material.

In a further subsidiary aspect, the extractor comprises an air knife. The use of an air knife disperses fumes rapidly away from the cutting surface to minimise the risk of a flame which might cause damage to the material and to the laser scanner.

In a further subsidiary aspect, the laser cutting machine further comprises a loading roller for presenting material to the cutting surface. The loading roller presents material, tension free, to the cutting surface. If a conveyor is provided, the loading roller presents material to the conveyor. Minimal to no manual operation from an operator is therefore required. In a preferred embodiment the

material may pass immediately from a printer to the cutting machine.

In a further subsidiary aspect, the laser cutting machine further comprises an unloading roller for unloading material from the cutting surface. An unloading roller removes cut material from the cutting surface to increase the speed and efficiency with which the laser cutting machine operates.

In a further subsidiary aspect, the laser cutting machine further comprises a camera which is configured to view the material on the cutting surface. It is often a requirement, at least in the print industry, to cut shapes that are already printed. Fabric will stretch and otherwise be distorted during the printing process but for applications such as clothing and apparel it is important that the finished cut pattern is the correct final shape. Also, prints often must contain additional information such as cut contours and require graphics. The advantage of incorporating a camera is that marks and other lines on a piece of material can be more effectively followed to produce a cut piece of material which is a correct final shape.

In a further subsidiary aspect, the gantry comprises a displaceable head on which the laser scanner is mounted, and said camera is mounted on said displaceable head. Positioning the camera on the same displaceable head as the laser scanner allows the camera and laser scanner to work conjointly to produce an accurately cut piece of material. Software and/or an operator can more accurately follow cutting or contouring lines when the camera is utilised.

In a further broad aspect, the invention provides a laser cutting system comprising a laser cutting machine and a printer; wherein the printer and laser cutting machine are configured such that material may pass immediately from the printer to the laser cutting machine.

This configuration is particularly advantageous because it provides a laser cutting system which minimises the amount of space and time required to print and cut a piece of material. More specifically, coupling a printer and laser cutting machine minimises the amount of manual work required by an operator so that a single operator can run multiple machines at the same time. Also, only one setup

process is required for the printing and cutting of material to take place. A computer program which runs the printer may also contain the required cutting profile and other cutting instructions, such as speed of cutting required, so that pieces of material are printed and cut without any intermediate manual work from an operator.

Brief Description of the Drawings

In the drawings:

Figure 1 shows a perspective view of a laser cutting machine in accordance with a preferred embodiment of the invention.

Figure 2 shows another perspective three quarter view from the rear of the laser cutting machine.

Figure 3 shows a perspective view from the side of the laser cutting machine.

Figure 4 shows a side view of the laser cutting machine.

Detailed Description of the Embodiments

Figure 1 illustrates a preferred embodiment of a laser cutting machine, generally referenced as 10. The laser cutting machine 10 comprises a table 11 with a cutting surface 12 on which a material is placed, in use, to be cut. The laser cutting machine further comprises a gantry 13 which extends across at least part of the width of the table 11 and, in a preferred embodiment, extends across the entire width of the table 11. A laser source 14 and a laser scanner 15 are provided which are connected and which, between them, produce and deflect a laser beam which is deflected towards the cutting surface 12 of the table 11 to cut a material.

The laser source and laser scanner are housed in discrete cases. The laser source 14 is static in use and only the laser scanner 15 is mounted onto and moveable on the gantry 13. The laser source 14 is mounted either on a part of the table 11 or on a part of the gantry 13 which is not displaced, or is fixed, in

use. In the preferred embodiment of Figure 1, the laser source 14 is attached to the gantry 13 but is statically located above the table 11 via a connecting arm 16. By keeping the laser source 14 motionless in use and moving only the laser scanner 15 to cut a material, the displaceable head 17 on which the laser scanner 15 is mounted is able to move much faster than would otherwise be possible due to the additional weight and sensitivity of the laser source. A static laser source 14 and moveable laser scanner 15, which is connected to the laser source 14, enables a larger amount of material, of any length or width, to be cut within a period of time with the same or a greater degree of precision. In a preferred embodiment, the laser scanner 15 mounted on the gantry 13 is configured to move at a speed of at least 1.5 meters per second and with an acceleration of gravitational force 1g. The stationary positioning of the laser source allows this to be achieved.

The gantry 13 extends across entire width of the cutting surface 12. The laser scanner 15 mounted on the gantry 13 is preferably capable of moving across a 5m or larger fabric width. The laser cutting machine 10 is also preferably configured to cut a strip of width approximately 100mm (measured longitudinally, perpendicular to the fabric width) at each pass in use. The motion of the laser scanner 13 is such that there is little or no deflection of the laser beam during motion. This eliminates the risk of distortions to the material as it is cut.

In the preferred embodiment of the figures, the laser scanner 15 comprises a number of mirrors to deflect the laser produced by the laser source 14 to move the laser beam in the Y axis, perpendicular to the gantry. In one embodiment, at least one mirror within the laser scanner 15 is adjustable to allow the angle of deflection of the laser to be changed. This configuration allows rapid movement of the laser scanner 15 and the mirrors mounted within it. In a further preferred embodiment, the laser source 14 or the laser scanner 15 comprises a collimator such as a collimating lens, instead of but preferably as well as the plurality of mirrors, to narrow the produced laser beam in order to minimise the spot size of the laser on the material. The collimating lens expands the laser beam up to a size of, preferably, 9.8mm which is set at a constant within +/- 0.2mm over the entire cutting width of the laser scanner.

In a yet further preferred embodiment, the laser scanner 15 is configured so as to deflect the laser beam produced by the laser source 14 in three dimensions. Deflecting the laser in three dimensions increases the area over which the laser scanner can cut material. In this preferred embodiment, the laser scanner comprises two deflecting mirrors to direct the laser beam in the X and Y axis. The two deflecting mirrors are preferably bend mirrors which steer the laser beam at 90 degrees into the plane of the laser scanner and onto the cutting surface. The bend mirrors are, in a preferred embodiment, set at 45 degrees or off 45 degrees. An additional moving lens (a collimator) is provided to ensure that the spot size of the laser scanner is kept constant and focussed over the entire cutting 'window' of the laser scanner. Without the moving lens, the spot size would likely increase at the edges of the cutting 'window'. Deflection in three dimensions also improves the versatility of the laser cutting machine 10. The gantry 13, i.e. frame, on which the laser scanner 15 is located allows the laser scanner 15 to move from left to right across the width of the table 11. By deflecting the laser in three dimensions, the laser scanner is able to function both longitudinally, and laterally across the table.

Incremental movement of a piece of material across the cutting surface 12 and movement of the laser scanner 15 across the entire width of the material allows a piece of material of any size to be processed.

In a preferred embodiment, the spot size of the laser scanner is 1/e2 or 165μm. In alternative embodiments, the spot size of the laser scanner may be smaller or larger depending on the cutting requirements of the operator.

In a preferred embodiment, to further improve the spot size and therefore efficacy of the laser cutting machine 10, the distance between the laser scanner 15 and the cutting surface 12 of the table 11 is between 350mm and 450mm. More preferably, the distance is approximately 400mm. With this distance between the laser scanner 15 and cutting surface 12, a shorter focal length lens can be utilised to minimise the spot size of the laser on the material. The laser scanner 15 is preferably positioned at 90 degrees, i.e. is perpendicular, to the plane of the cutting surface 12. In an alternative embodiment, the laser scanner 15 is set at an angle which is not perpendicular to the plane of the cutting surface 12.

In one embodiment, the laser cutting machine 10 further comprises a conveyor (not shown) for transporting material from one end of the table 11 to the other, preferably incrementally, as the material is cut. The conveyor preferably comprises a belt to form a conveying bed which ensures that the material is supported on the cutting surface 12. Other forms of conveyor, such as a series of motorised rollers, may alternatively be provided, but a belt is preferred to provide a uniform support to the material as it is processed.

In one embodiment, the laser cutting machine 10 further comprises an extractor (not shown) to remove or disperse fumes created by the laser scanner 15 at the cutting surface 12. Where an extractor is provided, extraction means are preferably located above and below the cutting media to effectively remove fumes and prevent a flame which might damage the material or laser cutting machine 10. Even more preferably, the extractor comprises an air knife.

To further reduce the amount of manual work required by an operator, the laser cutting machine 10 may comprise a loading roller and/or an unloading roller for loading and unloading a material to and from the cutting surface 12 of the table 11. A powered material roller 19, or de-reeler, is preferably provided to present the material to the cutting surface 12 tension free. Cut parts of material may be moved on to a collecting table or container, by the conveyor when it is present, but an unloading roller (not shown), or re-reeler, may be provided to allow multiple long shapes to be rolled for later handling and processing. In a preferred embodiment, where an unloading roller is also provided, the unloading roller is also powered to allow the material to be fed onto a collection area.

The material which has been cut by the laser cutting machine 10 may be passed through additional workstations that will add edge seaming, such as Beading or Kada strip in line with the cutting process. Rigid sheets will be fed onto a roller table for later removal. In one embodiment a sheet collecting station that stacks cut parts is provided. The sheet collecting station preferably stacks cut parts onto a pallet ready for removal from the machine 10.

In order to make the machine 10 as versatile and usable with other workstations

as possible, the table 11 preferably comprises a bottom surface 20 which allows the laser cutting machine 10 to be mounted on a work surface. In an alternative embodiment, which is not shown, the machine 10 is provided with legs to support itself. The legs may be adjustable to line the laser cutting machine 10 up with a printer or other workstation so that manual work by an operator in the processing of a material can be minimised.

It is often a requirement in the print industry to be able to cut shapes that are already printed. It is normal that fabric will stretch and distort during the print process, but for applications such as light boxes and apparel it is important that the finished cut pattern is the correct overall shape. In this case the print must contain some additional information such as a cut contour or indicators printed together with required graphics. In one embodiment, the laser cutting machine 10 comprises a camera (not shown) that is mounted and moveable on the same head 17 of the gantry 13 as the laser scanner 15. In use, the camera is configured to recognise marks on the material to ensure that the material is cut to the correct size and shape. This means that the final cut parts will be the correct size with a print located at the correct position. In an alternative embodiment, the camera is mounted on a separate head to the laser scanner 15 and is moveable separately from the laser scanner 15.

The position of the gantry is encoded using a linear encoder or rotating encoder and this information is fed back into the laser scanner to compensate for the motion of the scanner.

Control software is provided to control the cutting operation of the laser cutting machine 10. For example, where long panels are cut in segments or frames that are approximately 100mm long, the cutting information together with the cutting speeds and laser power will be passed to the laser scanner 15. Motion of the laser machine 10 will then automatically commence and the laser scanner 15 will deflect, in the Y direction, the laser beam produced by the laser source 14 towards the cutting surface 12 onto the cutting media in the correct shape necessary to process a thin strip. If the complexity of the part and the laser power required to cut the material exceeds the speed of travel of the moving gantry 13 the gantry 13 will be slowed or an additional scanner will be provided to finish the

cut shapes. In one embodiment, multiple laser scanners are provided to cut a piece of material.

Multiple laser sources may also be provided, or a single laser source provides multiple laser scanners with a laser beam to be deflected towards the cutting surface 12.

In a preferred embodiment, a laser cutting system is provided which comprises a laser cutting machine 10 and one or more other workstations such as a printer. In a particularly preferred embodiment, a printer is provided which precedes the laser cutting machine 10 so that material can be processed by the printer and the cutting machine automatically without manual work from an operator being required between the two machines. Only a single setup process is required when a printer and laser cutting machine are coupled in this way. Material output incrementally by the printer may be advanced incrementally by the cutting machine and cut in incremental segments or frames. This configuration allows material to pass immediately from the printer to the cutting machine. Where an operator wishes to feed the laser cutting machine 10 from multiple printers, the material will be presented to the cutting machine 10 on a roll. In this embodiment, the roll is mounted onto the rear of the laser cutting machine 10 and is fed through a roller onto a conveyor for cutting.

The complete cutting of panels over 10m long will enable fast production of long panels with an operator able to cope with a slow and steady, preferably incremental, advance of panels. Digital printers are capable of production of approximately 100 linear meters per hour. The laser cutting machine of a preferred embodiment is envisaged to cut faster than 100 linear meters per hour. The resolution of the laser cutting machine 10 is sufficiently high so that it is possible for the laser scanner 15 to engrave onto a material high resolution images as well as text and contour cutting.

In one embodiment, the cut panels are presented to an operator in a way which will enable him to roll the material back onto a reel, enabling a single operator to run multiple laser cutting machines.

Claims

1. A laser cutting machine comprising
a table having a cutting surface on which, in use, a material to be cut is located;
a gantry which extends across at least part of the width of the cutting surface;
a laser source;
and a laser scanner;
wherein, in use, the laser source is static and the laser scanner is mounted and displaceable along the gantry; whereby the laser scanner deflects the laser produced by the laser source towards the cutting surface.

2.A laser cutting machine according to claim 1, wherein the laser scanner comprises a plurality of mirrors which deflect the laser produced by the laser source towards the cutting surface.

3.A laser cutting machine according to claim 2, wherein at least one of said mirrors is adjustable within the laser scanner to change the angle of deflection of the laser produced by the laser source.

4.A laser cutting machine according to claim 2 or claim 3, wherein the plurality of mirrors are each plane mirrors.

5.A laser cutting machine according to any of the preceding claims, wherein the laser scanner comprises a collimator.

6.A laser cutting machine according to any of the preceding claims, wherein the laser scanner is configured to deflect a laser with a spot size of 1/e2.

7.A laser cutting machine according to any of the preceding claims, wherein the laser produced by the laser source is deflected by the laser scanner in three dimensions.

8.A laser cutting machine according to any of the preceding claims, wherein the distance between the laser scanner and the cutting surface is between 350mm

and 450mm.9.A laser cutting machine according to claim 8, wherein the distance between the laser scanner and the cutting surface is approximately 400mm.

10.A laser cutting machine according to any of the preceding claims, wherein the table comprises a conveyor for conveying a material along the length of the cutting surface.

11.A laser cutting machine according to any of the preceding claims, wherein, in use, the laser scanner is travels at substantially 90 degrees to the cutting surface.

12.A laser cutting machine according to any of the preceding claims, wherein the laser scanner is configured to move at a speed of at least 1.5 meters per second along the gantry.

13.A laser cutting machine according to any of the preceding claims, wherein the machine further comprises an extractor for removing fumes created by the laser scanner at the cutting surface.

14.A laser cutting machine according to claim 13, wherein the extractor comprises an air knife.

15.A laser cutting machine according to any of the preceding claims, further comprising a loading roller for presenting material to the cutting surface.

16.A laser cutting machine according to any of the preceding claims, further comprising an unloading roller for unloading material from the cutting surface.

17.A laser cutting machine according to any of the preceding claims, further comprising a camera which is configured to view the material on the cutting surface.

18.A laser cutting machine according to claim 17, wherein the gantry comprises a displaceable head on which the laser scanner is mounted, and said camera is mounted on said displaceable head.

19.A laser cutting machine substantially as hereinbefore described with reference to and as illustrated by the accompanying figures.

20.A laser cutting system comprising a laser cutting machine in accordance with any of the preceding claims and a printer; wherein the printer and laser cutting machine are configured such that material may pass immediately from the printer to the laser cutting machine.

21.A laser cutting system substantially as hereinbefore described with reference to and as illustrated by the accompanying figures.

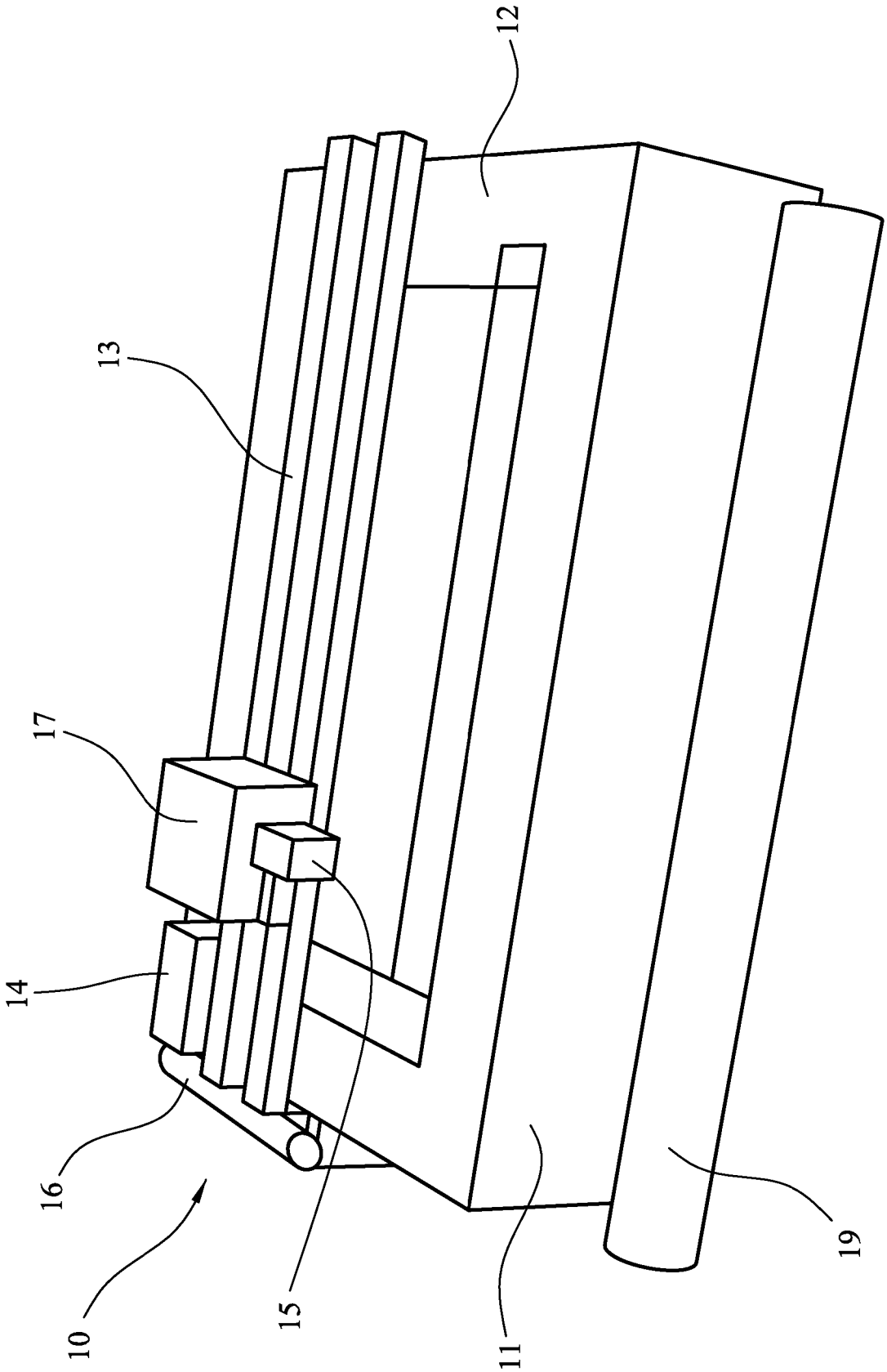

Figure 1

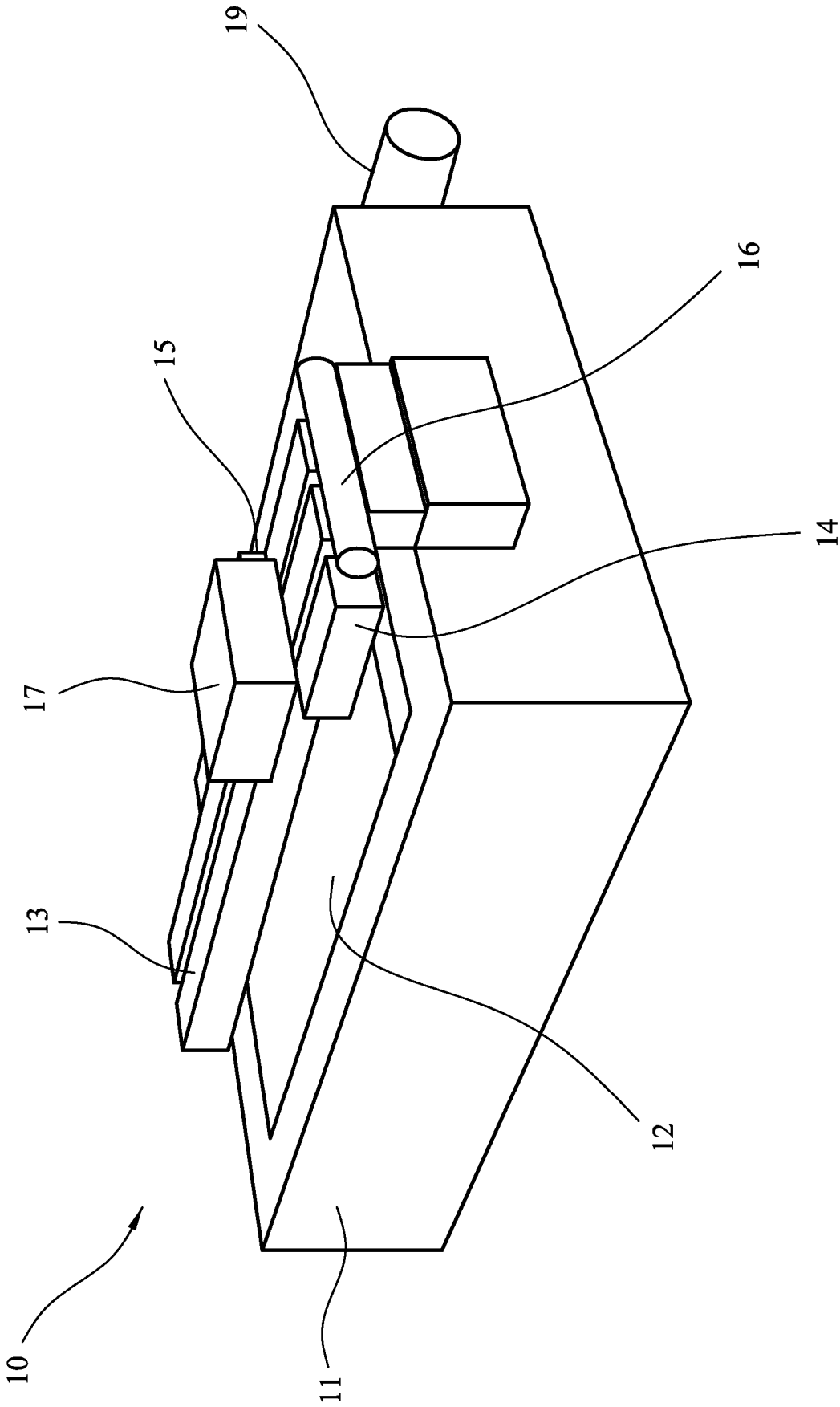

Figure 2

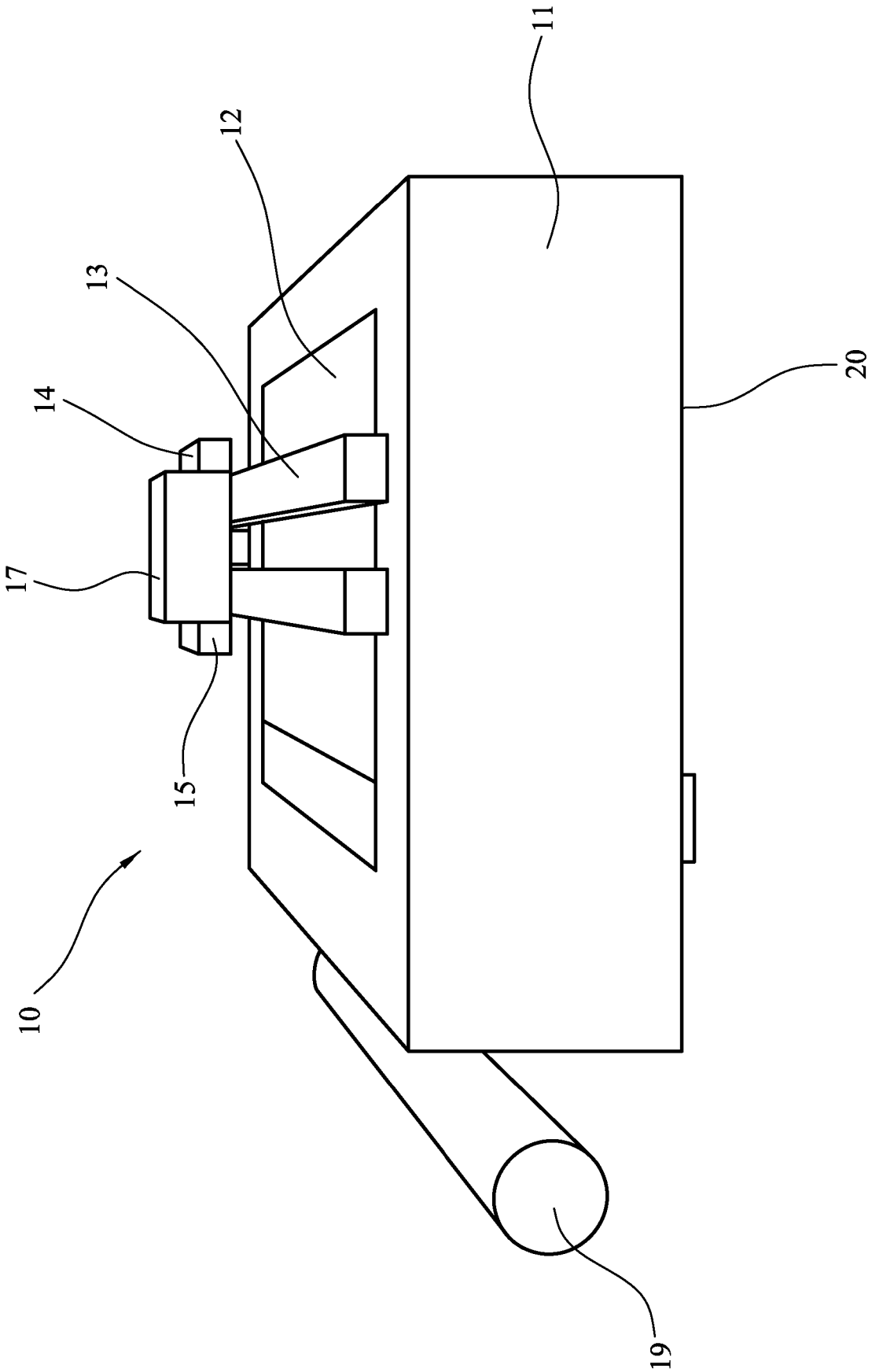

Figure 3

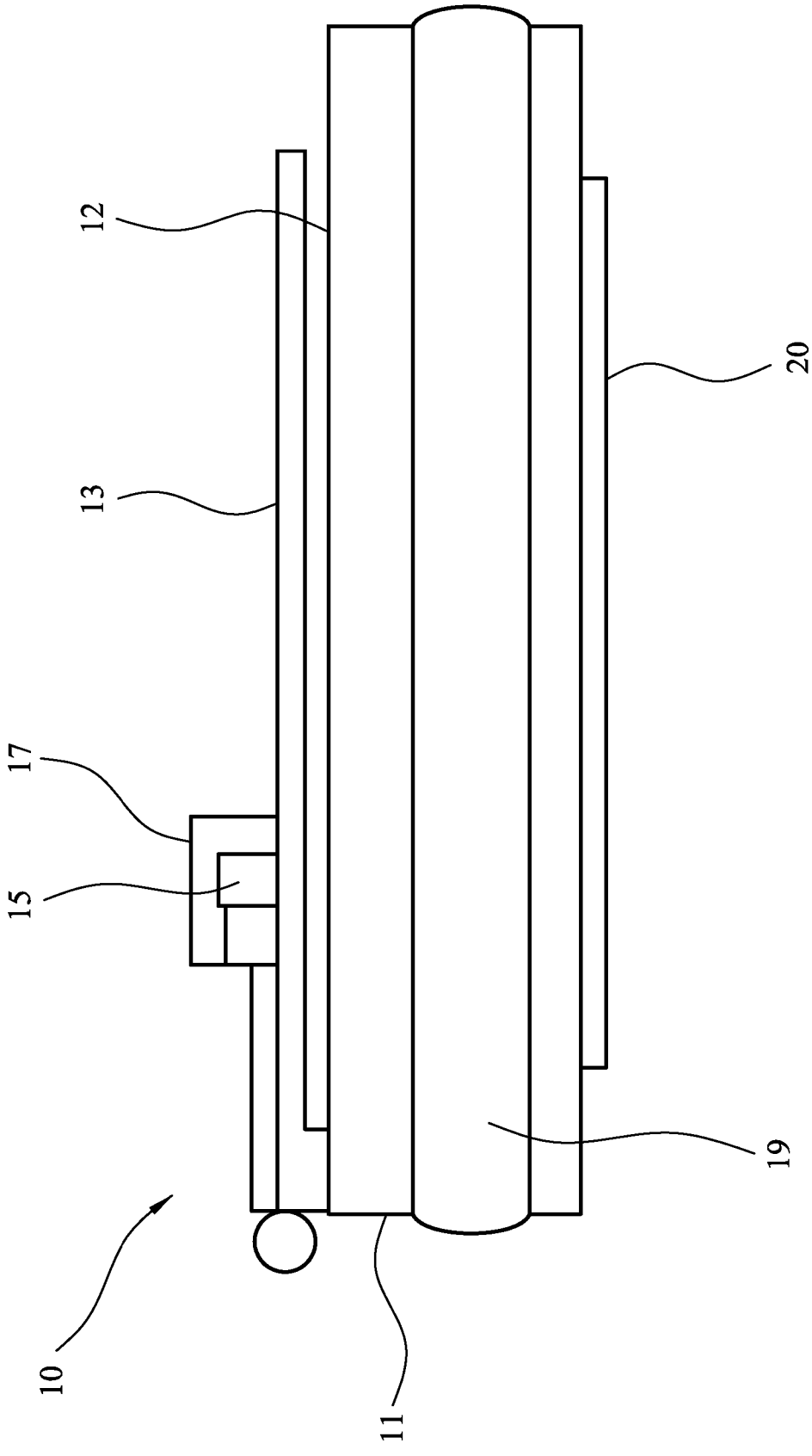

Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/051948

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K37/02 B23K37/04 B23K37/047 B23K26/03 B23K26/06
B23K26/08 B23K26/38 B23K26/142 B23K26/082 B23K26/044
ADD. B23K103/00
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 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 2007 230230 A (OYO KOGAKU KENKYUSHO) 13 September 2007 (2007-09-13) paragraph [0015]; figure 1	1,3-6, 19,21
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[X] Further documents are listed in the continuation of Box C.

[X] 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
31 October 2017	13/11/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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