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WO 2019/012566 A1 **US 9868302 B1**
US 5614115 A
https://www.youtube.com/watch?v=Wszt7kY3JSM "Laser Cutting Dye Sublimation - Contour Cut Vision" Published 9th February 2018.
https://www.youtube.com/watch?v=In_Rafksg0c "Laser Cutting Printed Textiles and Fabrics - Contour Cut Vision - Golden Laser", published 20th December 2013.
"Laser Cutting Printed Fabrics - Contour Cut Vision" promotional material by CadCam Technology Ltd. Dated to 2016 at the earliest.

(58) Field of Search:
Other: **Online Search**

(54) Title of the Invention: **Automatic cutting of shapes from sheet material**
Abstract Title: **Automatic Cutting of Shapes from Sheet Material**

(57) Method of operating a numerically controlled cutting machine to cause it to cut out shapes from a sheet material corresponding to closed path outlines pre-printed on the material, comprising; i) moving the sheet material 1 from a reservoir 2 of pre-printed sheet material in a constant forward direction 3 past one or more cameras or optical sensors 6 and towards a cutting table 4 where the shapes are to be cut; ii) using the one or more cameras or optical sensors to detect continuous lines pre-printed on the sheet material as it moves from the reservoir towards the cutting table; iii) processing the resulting continuous line data to identify closed loop shapes 5a/5b printed on the sheet material; iv) deriving cutting command data from the identified shapes, and, v) transferring the cutting command data to the cutting machine to cause the machine to cut the identified shapes from the sheet material. The data processing step may comprise ignoring any closed loop shapes contained within the boundaries of other larger closed loop shapes. The cutting sheet may be held on the cutting table by air suction. A second aspect is directed towards a numerically controlled cutting apparatus.

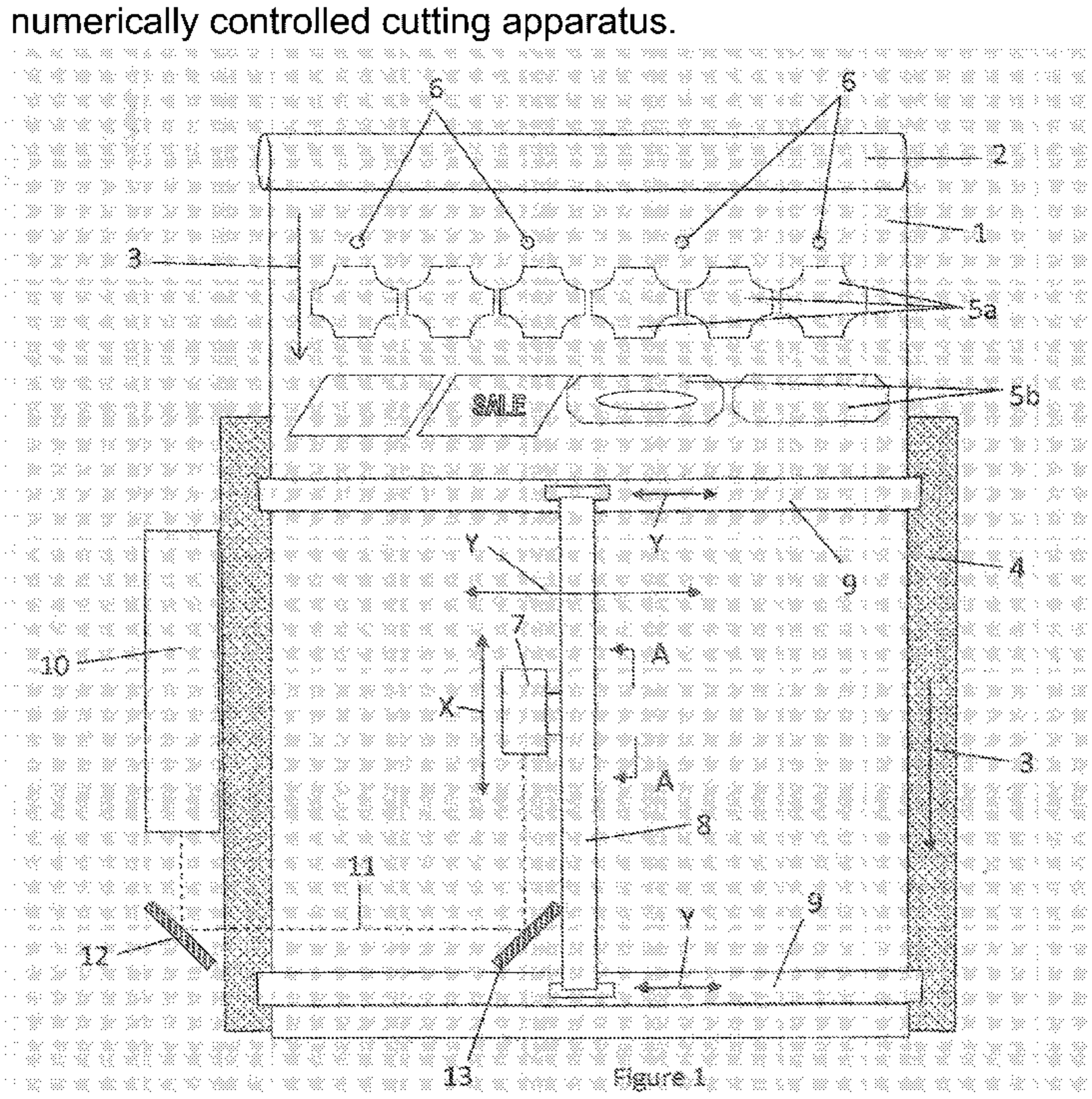

Figure 1

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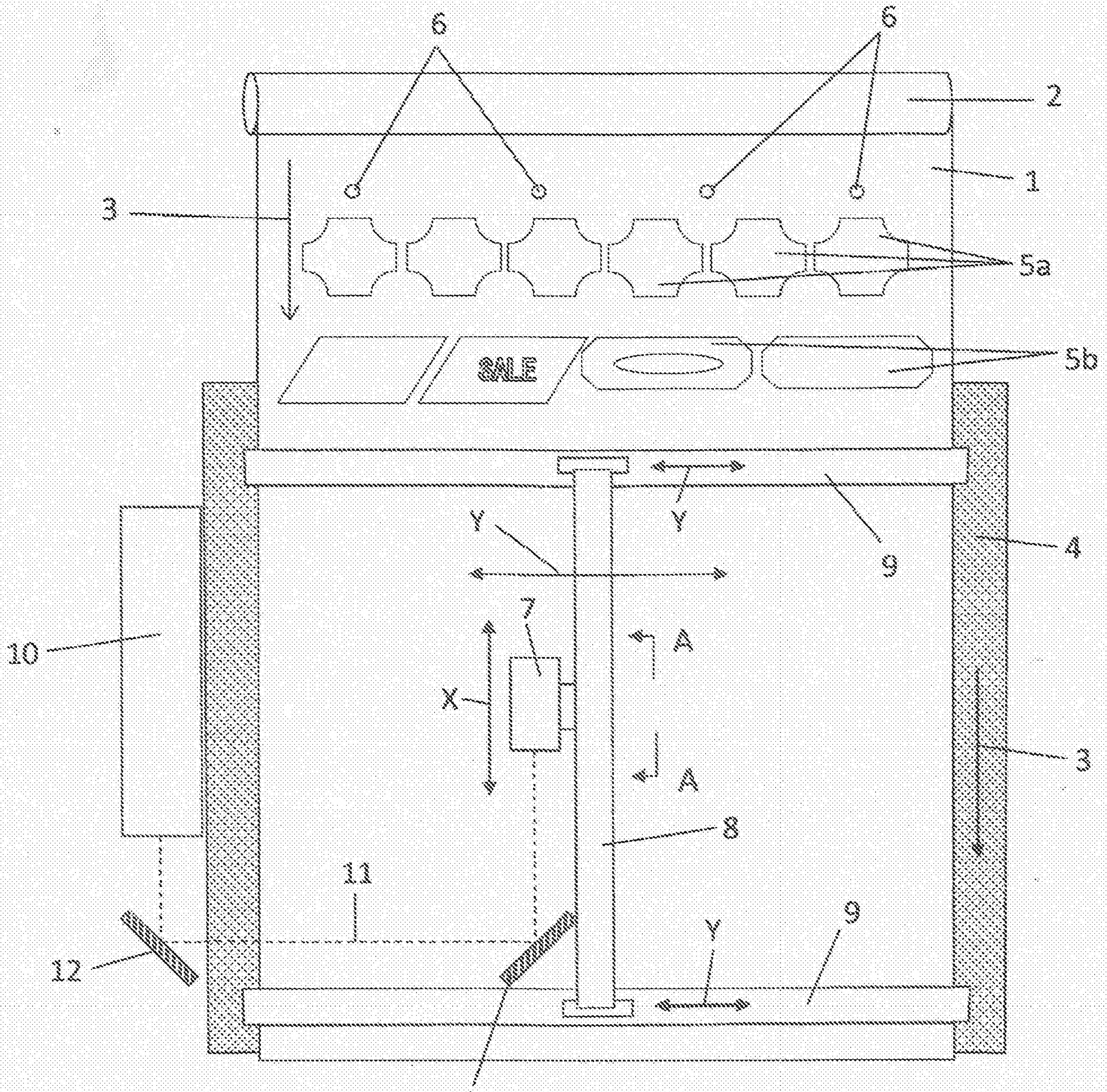

Figure 1

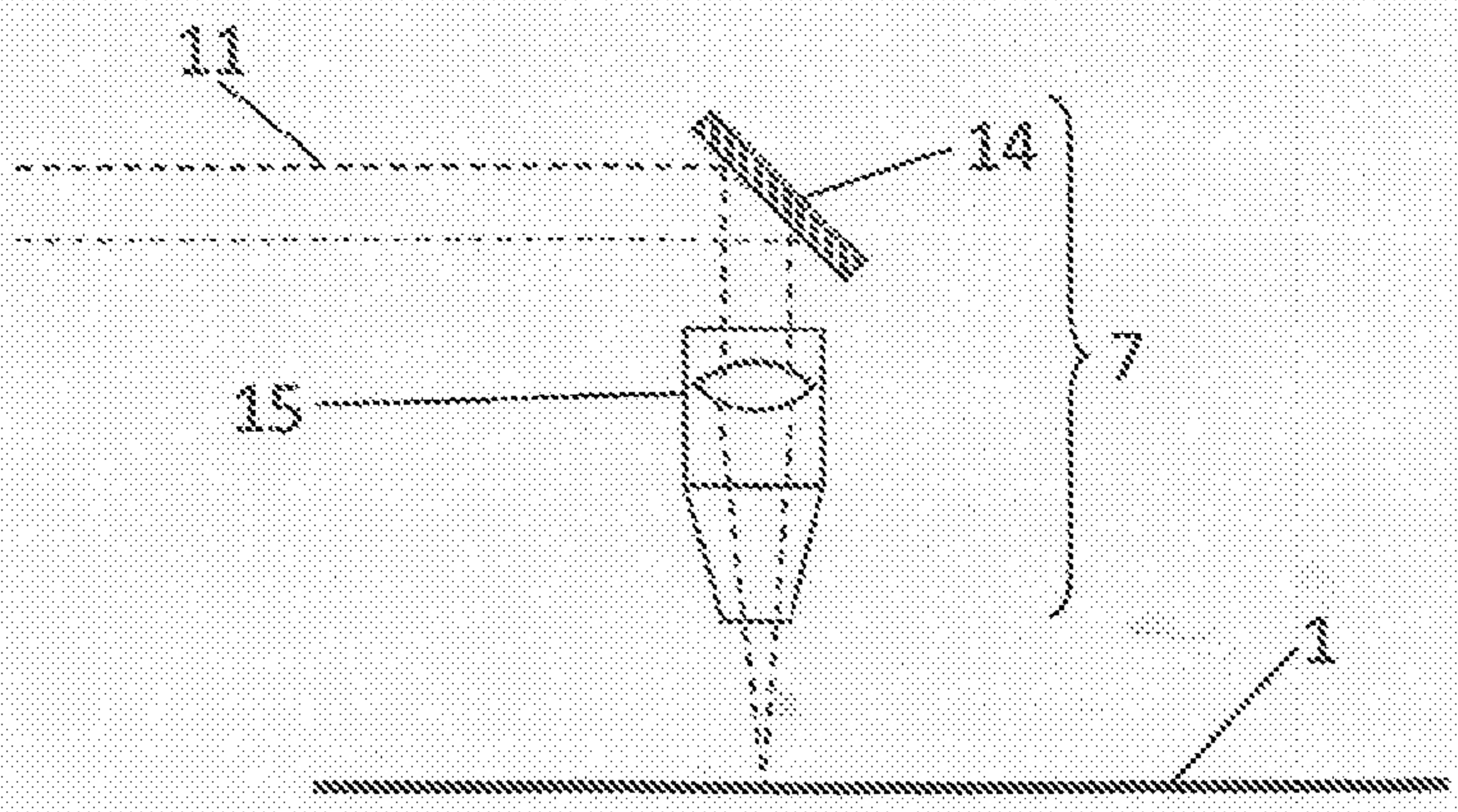

Figure 2

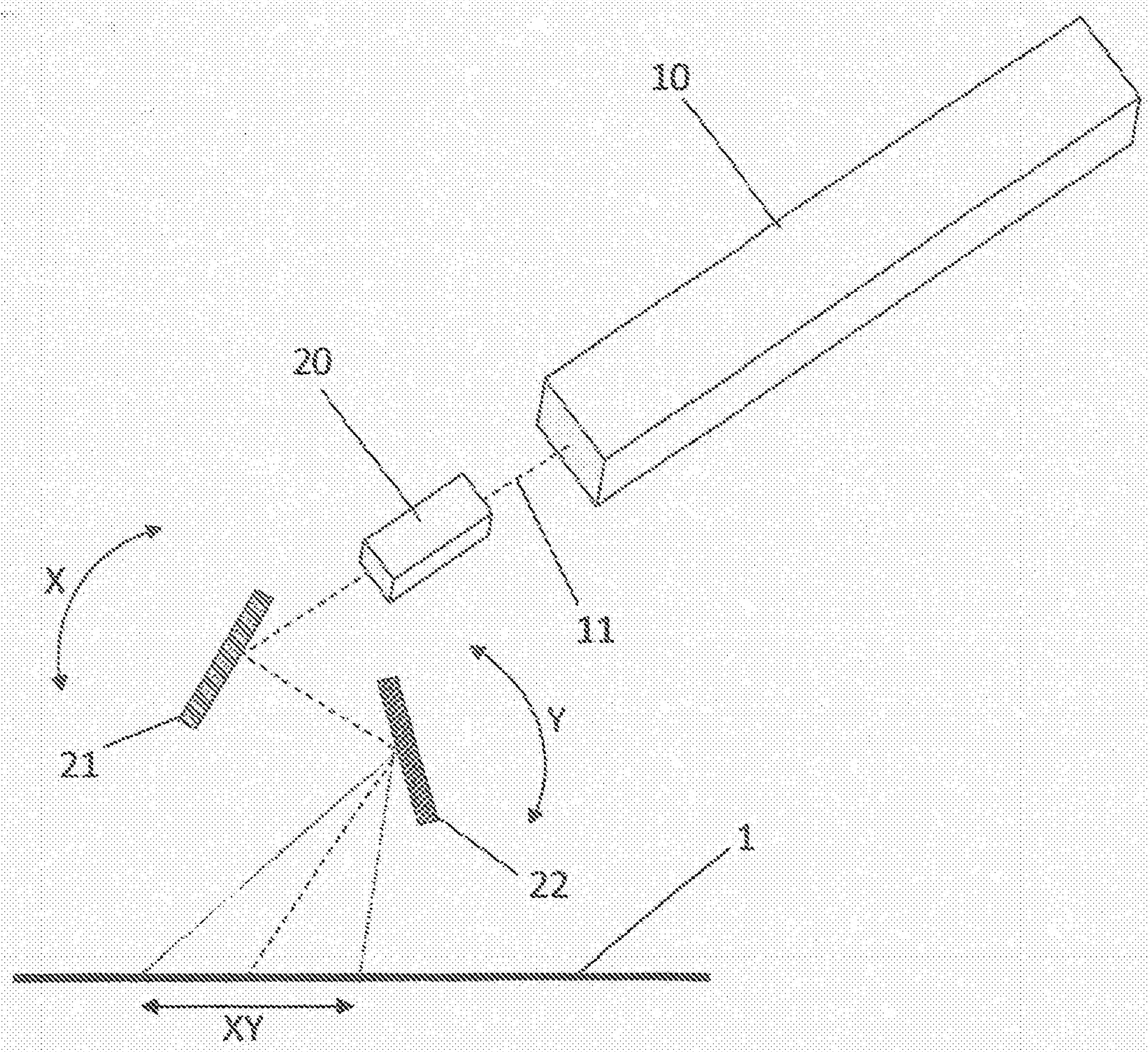

Figure 3

AUTOMATIC CUTTING OF SHAPES FROM SHEET MATERIAL

Technical Field

The invention relates to the automatic cutting of shapes from sheet material and provides a method of programming and operating a numerically controlled cutting machine, to cut out shapes pre-printed onto the sheet material. The cutting machine may be any machine which has a numerically controlled cutting head, for example a laser cutter, a hot knife cutter, a water jet cutter, a hot air jet cutter or a milling cutter, although the invention is particularly suited to laser cutters. The invention also includes such cutting machines when organized and programmed according to the invention.

In the following description, the invention will be described principally by reference to numerically controlled laser cutters, but it must be understood that this is by way of example, and that all other types of cutting machines are included within the scope of the invention, as long as they are under numerical control and suited for the cutting out of shapes from sheet material.

The pre-printed sheet material to be cut according to the invention may be flexible, such as a fabric, textile or flexible thermoplastic sheet, or may be a rigid or semi-rigid board material such as cardboard. Examples of flexible sheet materials that may be cut according to the invention are rolls of pre-printed textile materials suitable for use in flag, banner, clothing or footwear manufacture, real or simulated leathers, and rolls of vinyl sheet. All such flexible sheet materials are commonly cut into separate pieces for assembly into clothing, footwear, flags or banners (although that list of end uses is by no means a comprehensive list).

The sheet material may have a plain, self-coloured or printed background, but it is a feature of the invention that cutting shape outlines are pre-printed on the sheet materials, and that the cutting machine follows those cutting shape outlines to cut through the sheet material to create the final cut shapes. Other features that may be printed on the sheet material may be decorative, such as pictures, or informative, such as text, or both.

Technical Background

US-A-5614115 discloses one known laser cutter for cutting out shapes from sheet material. The sheet material is passed over a support roller onto which a collimated laser beam is focussed, and by controlling the lateral movement of a laser cutting head together with the forward and rearward movement of the sheet material, the shape outline is cut from the sheet. Historically the sheet material had been marked with location marks on a border of the sheet to enable the shapes to be cut from an intended location on the sheet material, and the shapes themselves had been pre-programmed into the laser cutter control program as cutting command data, but US-A-5614115 added the improvement that the shapes could be printed directly onto the sheet material and the laser cutter could be programmed to detect those pre-printed shapes and to derive cutting command data to control the cutting head to follow the pre-printed shapes, eliminating the need for border-printed location marks. The camera/laser cutter combination of US-A-5614115 operates in a cycle of three consecutive modes. In a first, data capture, mode the sheet material is passed over the same support roller with the laser beam turned OFF, and a camera or other optical recognition device mounted on the same movable head that mounts the laser cutting head is used to scan the sheet material as the sheet material is moved progressively over the support roller, and to identify the shape outlines printed on the sheet material. That optical recognition device is then turned OFF and the sheet material is drawn back over the support roller to its start position, while in a second, data processing, mode the shape identification data captured is processed to create cutting command data for the laser cutter. In a third, cutting, mode the laser beam is turned ON and the cutting command data is used to control both the lateral movement of the laser cutting head and the forward and rearward movement of the sheet material over the support roller, to cause the laser to cut the desired outline from the sheet material.

US-A-9868302 discloses a laser cutting machine which cuts a continuous fabric into pieces for stitching together to make clothing. In that machine all the data to identify the shapes to be cut is pre-programmed into the laser cutting machine together with printing command data, and as plain unprinted fabric is unrolled from a fabric roll it passes first through a printer where the fabric is printed with cutting and garment assembly data, optionally together with a decorative pattern. The fabric then passes to a laser cutting area where the shapes are cut out. The printing ink used for the cutting and garment assembly data is a fluorescent ink which is invisible to the human eye under normal lighting conditions, but which can be seen by the human eye or by a camera under ultraviolet light. UV-responsive image sensors downstream of the laser cutter monitor the process and can control the laser cutter, but the basic cutting command data is already pre-programmed into the machine for the initial printing stage, and the shapes have been cut before the fabric reaches the UV-responsive image sensors.

An almost identical concept is disclosed in WO-A-2019/012566, which uses a similar combined printing and cutting machine. The initially plain fabric is printed with pre-programmed shapes and other potentially useful information using ink which is substantially invisible to the human eye. After printing the fabric with those shapes to be cut and other potentially useful information, the fabric is unrolled further to pass to the cutting part of the machine where the shapes to be made up into garments are cut out. As with US-A-9868302, the shapes to be cut are pre-programmed into the machine together with the printing command data. As with US-A-9868302, UV-cameras downstream of the cutter section are responsive to the data printed on the fabric and retrieve information therefrom, and that information is used to control the cutting and potential further treatment of the fabric. As with US-A-9868302, however, the cameras scan the fabric only after the shapes have been cut.

Concepts common to both US-A-9868302 and WO-A-2019/012566 are that the shapes to be cut from the fabric are printed as part of the same machine that cuts out those shapes, and that the UV-responsive cameras or sensors are located downstream of the cutting area. That location of the cameras or sensors means that their use is very limited in the control of the laser cutter, effectively being limited to stopping the machine if the fabric is wrongly positioned on the cutting table. That is not a problem however in the context of the general disclosure of the use of those combined printing and cutting machines, because the accurate shapes to be cut from the fabric are already present in the control computer as pre-programmed data.

The present invention aims to create a novel machine which does not require pre-programmed cutting command data in order to cut specific and accurate shapes from a roll of sheet material, as do US-A-9868302 and WO-A-2019/012566, and which does not have to operate intermittently as does the machine of our own US-A-5614115. The invention also provides a method of programming and operating such a machine.

Summary of the Disclosure

The invention provides a method of operating a numerically controlled cutting machine as defined in claim 1. The invention also provides a numerically controlled cutting machine according to claim 6.

The machine of the invention is preferably a laser cutting machine which automatically cuts shapes from a plain or patterned sheet material, cutting outlines which are already printed on the sheet material. The sheet material may be, for example, a pre-printed fabric or vinyl sheet drawn from a roll, or a rigid or semi-rigid sheet material such as cardboard fed from a stack. The means for obtaining the cutting data does not rely on data pre-programmed into the machine. When a new batch of material is initially fed to the machine, there is no requirement to feed to the machine image data or cutting command data to control the cutter head and to tell it what outlines are to be cut from the sheet material as it passes over the cutting table. No shape or cutting command data is pre-programmed into the machine. That cutting command data is obtained entirely from the outline or outlines printed on the sheet material as read and interpreted by the one or more cameras or optical sensors as the sheet material approaches the cutting table. That shape outline or those shape outlines printed onto the sheet material may have been printed at a different geographical location and perhaps some considerable time before the sheet material is fed to the cutting machine. The one or more cameras or optical sensors of the cutting machine of the invention is or are located upstream of the cutting table and focussed on the sheet material to detect cut shape outlines already printed on the sheet material. The one or more cameras or optical sensors feed their collected image data to a controller which, if a plurality of cameras or optical sensors is used, stitches together the image data from those cameras or optical sensors and which optionally uses image enhancement algorithms to develop reliable cutting command data which faithfully analyses the shapes pre-printed on the sheet material. The pre-printing of those shapes may use any suitable ink or print medium that can be detected by the camera or cameras, including ordinary printing ink of any colour or fluorescent ink as taught in US-A-9868302 or WO-A-2019/012566. Preferably however a high contrast between the lines defining the outline shape to be cut and the surrounding background is desirable. The means for obtaining the cutting command data should, if the sheet material includes pre-printed decorative patterns, be capable of distinguishing between those decorative patterns and continuous lines which define the shape outlines, but that would be a relatively straightforward shape recognition aspect of the control program processing the data detected by the one or more cameras or optical sensors.

One outstanding advantage of the machine of the invention is that cutting can run continuously, unlike the machine of our US-A-5614115 which required a pause between the scanning phase and the cutting phase while the direction of movement of the fabric was reversed and cutting command data was generated. No reversal of the direction of movement of the sheet material is involved when operating the method of the invention, so no strengthening backing material is required to hold the sheet material flat as the feed direction is reversed. Using the machine of the invention the cutting command data is created on the fly, as the sheet material advances from the detection zone, over which the one or cameras or optical sensors is or are focussed, to the cutting table. No location marks are required on the borders of the sheet material as in most laser cutters, because the cutting command data identifies the actual lines printed on the sheet material where the cuts have to be directed. Most importantly, the machine according to the invention can cut any printed shape from any sheet material with no pre-programming of the cutting head being required other than potentially a control to respond to the thickness and nature of the material itself. That is something that can be entered into the machine by an operator whenever a new roll or reservoir of pre-printed sheet material is loaded into the machine, and the operator does not need to know the nature of the outline shapes printed onto that sheet material. He or she needs to know only the thickness and nature of the material itself. One possible means of avoiding even this small element of operator control is for command instructions for the energy level of the laser beam to be printed on the sheet material itself, possibly on a border of the sheet material beyond the cutting zone.

The detection, in the data processing step, of the closed loop shapes printed on the sheet material may comprise ignoring any closed loop shapes contained within the boundaries of other larger closed loop shapes, or alternatively may comprise identifying closed loop shapes even when they are contained within the boundaries of other larger closed loop shapes. For example, if the sheet material being presented to the machine for cutting is sheet material for banners or point-of-sale displays, it may contain printed letters or numbers within the closed loop shapes to be cut out, and it would be undesirable for the data processing step to provide cutting command data to cut around those letters or numbers which are intended to be retained simply as printed information on the final cut-out shapes. Alternatively, if the sheet material is fabric printed with clothing design outline shapes, it may (or may not) be desirable for the cutting head to cut out shapes from within the identified clothing design closed loop outline shapes, to create cut-out portions in the individual cut clothing panels. The choice between cutting and ignoring closed loop shapes printed on the sheet material wholly within other larger closed loop shapes is a selection that is conveniently under the control of an operator of the machine who is able to switch between those two alternative shape identification modes depending on the nature of the job in hand. Alternatively, it may be an automatic selection in response to a command code printed on the sheet material, for example at a border portion beyond the cutting zone, so that the operator need not know the final use intended for the sheet material being cut.

Brief Description of the Drawings

Figure 1 is a schematic plan view of a laser cutting machine according to the invention;

Figure 2 is a schematic section taken along the line A-A of Figure 1; and

Figure 3 is a schematic illustration of a galvo focussing head mounting for a laser cutting machine according to the invention.

Detailed Description of Embodiments

Embodiments of the present disclosure will now be described by way of example only and with reference to the accompanying drawings.

Referring first to Figures 1 and 2, the cutting machine is a numerically controlled laser cutter for cutting individual panels from a continuous roll of flexible pre-printed material such as fabric. The fabric 1 is initially wound on a roll 2 which creates the fabric reservoir. The fabric 1 is withdrawn from the roll 2 by a stepping motor which rotates the roll 2 in the fabric withdrawal direction illustrated by arrow 3 in response to sensor means (not shown) which monitors the fabric movement to maintain the withdrawal speed at precisely the speed of a conveyor table 4. The conveyor table 4 is the cutting table of the laser cutter, and is the top surface of any suitable conveyor such as a belt conveyor or a slatted conveyor, and is preferably perforated so that air suction from below the conveyor table 4 draws the fabric on the table into close flat contact with the table surface for precise handling of the fabric. Although not illustrated in Figure 1 or Figure 2, the roll 2 may be laterally movable to keep the unrolling fabric 1 in precise alignment with the conveyor table, to avoid any creasing or wrinkling of the withdrawn fabric on its way to the table 4.

Figure 1 shows two rows of shapes 5a and 5b pre-printed on the fabric 1. It is purely for ease of illustration that further shapes are not shown in Figure 1 on the advance portion of the fabric 1 which lies over the cutting table 4. Of course, it would normally be the case that the entire surface of the fabric would be pre-printed with such outline shapes to be cut out from the advancing fabric. The shapes may be regular repeating shapes, as illustrated in row 5a, or may be different shapes, as illustrated in row 5b. As the fabric 1 is taken from the roll 2 the cutting machine has no pre-programmed data identifying either the shapes printed on the fabric or the cutting data necessary to cut those shapes from the fabric.

The fabric movement is in the forward direction 3 only. As the fabric advances towards the cutting table 4 it passes beneath a row of cameras 6. Four such cameras 6 are illustrated in Figure 1, but the number is immaterial. What is important is that their viewing angle is sufficient that the entire width of fabric is visible. Where more than one camera is used, as in Figure 1, the combined image data captured by the cameras 6 is stitched together to create a single scan of the entire fabric width. Initially the cameras process the captured image data to identify continuous lines printed on the fabric 1. If necessary, image enhancement algorithms may be used to improve the clear identification of those sensed continuous lines. Further processing is then used to identify whenever those identified lines form closed loop shapes, as do all of the shapes in row 5a. All other image data is discarded. Finally that data identifying the closed loop shapes is further processed into cutting command data for the laser cutter, so that when the shapes are over the cutting table 4 in the cutting zone, a laser cutting head 7 is controlled to cut along the detected lines to separate from the fabric 1 the individual detected shapes.

Of the printed shapes to be cut from the sheet material, Figure 1 shows two alternatives in row 5b. In one of the parallelogram shapes the word “SALE” appears. That is to illustrate a potential banner or point-of-sale flag which might be cut from the sheet material. If such an item were to be cut from the sheet material 1 then it would no doubt be desirable that the laser cutting head should ignore the actual lettering and cut only around the outside of the parallelogram. To achieve that result, the further processing of the data identifying the parallelogram closed loop shape should follow an algorithm that ignores any continuous line data identified as lying within an outer closed path outline, namely the parallelogram shown by way of example in Figure 1. Thus, only the outer closed loop shape would be converted into cutting command date for the laser cutter. Another alternative illustrated in row 5b of Figure 1 is an octagonal outer closed loop shape which has within its outline an ellipse. For some end uses of the cut sheet material it would be desirable for the ellipse to be cut together with the outer octagon. For example, the sheet material might be fabric and the printed shapes might be the outlines of panels to be cut from the fabric for making up into garments or footwear. For such an intended end use, the algorithm under which the data identifying the closed loop shapes is converted into cutting command data should not ignore any continuous line data identified as lying within the outer closed path outline and should instead generate cutting command data which cuts around all identifiable closed loop shapes.

The intended garment panel (shown in Figure 1 as an octagon purely by way of example) would then be cut from the fabric together with the central cut-away ellipse. It is feasible that a command code specifying which algorithm is appropriate for the intended end use could be printed on the fabric, possibly in a margin where it would not be confused with a cutting pattern; or alternatively the operator of the machine could choose between which of the two algorithms to use.

The laser cutting head 7 illustrated in Figures 1 and 2 is mounted on a guide rail 8 and is movable reciprocally along the rail 8 in response to an X direction component of the cutting command data. That guide rail 8 itself is mounted on a pair of guide rails 9 and is movable reciprocally along the rails 9 in response to a Y direction component of the cutting command data, so that combined movement of the laser cutting head 7 and the guide rail 8 enables the cutting head to trace the outline of the detected shapes. The X and Y directions of movement are indicated by double-headed arrows X and Y in Figure 1. The laser itself is illustrated schematically with the reference 10, with the laser beam showing as a broken line 11. That laser beam is reflected by two fixed mirrors 12 and 13 each at 45 degrees to the laser beam path, to reflect the beam 11 onto a third mirror 14 carried on the cutting head 7. A focussing lens 15 on the cutting head 7 then focuses the laser beam onto the fabric 1 on the cutting table 4.

As the cut pieces of the sheet material progress beyond the cutting table 4, they may be allowed to fall into collection baskets (not illustrated) or passed to another conveyor for presenting the cut pieces to an operator or robot downstream to be picked from that conveyor and sorted for further processing. The speed of feeding the sheet material in the direction of the arrow 3 is preferably varied to match the optimum cutting speed, so that there is a constant and uninterrupted passage of the sheet material though the machine.

There are a number of advantages deriving from the machine of the invention and its method of operation. Clearly one prime advantage is the ability of the laser cutter to cut around any closed loop pattern printed on the sheet material even though when the sheet material is first loaded into the cutting machine the laser cutter is devoid of any information or programming data indicating the shape and location of the shapes to be cut. Speed of operation is another important advantage. Cutting speeds are generally far faster than printing speeds, so the cutting is not slowed down by first having to print the fabric, as in US-A-9868302 and WO-A-2019/012566. The sheet material may have been printed by any printing method, including sublimation print transfer methods, whereas the printing demanded by US-A-9868302 and WO-A-2019/012566 must be line by line printing using a scanning print head. Cutting of the pre-printed sheet material can be continuous, unlike US-A-5614115 which requires a pause while the fabric direction of movement is reversed. Indeed, the pace of throughput of the sheet material through the machine is governed only by the cutting speed. The speed of a laser cutter can be increased beyond the speed achievable according to Figures 1 and 2 by using a galvo focussing cutting head mounted over the cutting table in place of the mirrors 12 and 13, the cutting head 7 and the rails 8 and 9 of Figure 1. Such a galvo focussing cutting head is illustrated schematically in Figure 3. In that Figure the laser is again given the reference number 10, but the laser beam 11 is passed first through a dynamic focussing and collimating lens 20 and then reflected by pivotable mirrors 21 and 22. The pivotal axes of the two mirrors are mutually perpendicular, providing pivotal mirror movements to move the laser focus point in the X and Y directions. That pivoting movement of the two mirrors 21 and 22 is illustrated by double-headed arrows X and Y, resulting in a final range of movement of the focus point of the laser beam 11 indicated schematically by the double-headed arrow XY. The pivoting movement of the mirrors, under the control of the cutting command data, can move the point of focus of the laser beam over the sheet material on the cutting table far more rapidly than the sliding cutting head control of Figures 1 and 2, so significantly faster throughput of the sheet material is possible. Of course, the throughput through the machine of Figures 1 and 2 or the machine of Figure 3 can be increased even further by having more than one cutting head in each machine, so that more than one closed loop shape can be cut from the sheet material simultaneously.

Although exemplary embodiments have been described in the preceding paragraphs, it should be understood that various modifications may be made to those embodiments without departing from the scope of the appended claims. Thus, the breadth and scope of the claims should not be limited to the above-described exemplary embodiments.

Any combination of the above-described features in all possible variations thereof is encompassed by the present disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like, are to be construed in an inclusive as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

Claims

1. A method of programming and operating a numerically controlled cutting machine to cause it to cut out shapes from a sheet material corresponding to closed path outlines pre-printed on that sheet material, which comprises:

moving the sheet material from a reservoir of pre-printed sheet material in a constant forward direction past one or more cameras or optical sensors and towards a cutting table where the shapes are to be cut;

using the one or more cameras or optical sensors to detect continuous lines pre-printed on the sheet material as it moves from the reservoir towards the cutting table;

processing the continuous line data detected by the one or more cameras or optical sensors to identify closed loop shapes printed on the sheet material;

deriving cutting command data from the identified shapes; and

transferring that derived cutting command data to the cutting machine to cause the machine to cut the identified shapes from the sheet material as it passes over the cutting table, following the continuous lines pre-printed on that sheet material.

2. A method according to claim 1, wherein the data processing step comprises ignoring any closed loop shapes contained within the boundaries of other larger closed loop shapes.

3. A method according to claim 1, wherein the data processing step comprises identifying closed loop shapes even when they are contained within the boundaries of other larger closed loop shapes.

4. A method according to any preceding claim, wherein the sheet material is a flexible sheet material and the reservoir is a roll from which the sheet material is drawn and moved in its constant forward direction towards and over the cutting table.

5. A method according to any preceding claim, wherein the cutting table is a perforated conveyor style moving cutting table and the sheet material is held firmly on the cutting table by air suction as it is cut.

6. A numerically controlled cutting machine, comprising:

means for moving sheet material from a reservoir of pre-printed sheet material in a constant forward direction towards and over a cutting table;

one or more cameras or optical sensors located directly over the sheet material as it passes from the reservoir towards the cutting table;

means for detecting, using the one or more cameras or optical sensors, continuous lines pre-printed on the sheet material as it moves from the reservoir towards the cutting table;

means for processing the continuous line data detected by the one or more cameras or optical sensors to identify closed loop shapes printed on the sheet material;

means for deriving cutting command data from the identified shapes; and

means for transferring that derived cutting command data to a cutting head of the cutting machine to cause the machine to cut the identified shapes from the sheet material as it passes over the cutting table, following the continuous lines pre-printed on that sheet material.

7. A machine according to claim 6, wherein the cutting head is a laser cutting head.

8. A machine according to claim 7, wherein the cutting head is a mirror and laser beam focussing head mounted on a rail over the cutting table so as to be reciprocally slidable in an X direction along that rail, the rail itself being mounted between a pair of rails over the cutting table so as to be reciprocally slidable in a Y direction along those rails, the reciprocal sliding in the X and Y directions being in response to the derived cutting command data to cause the cutting head to follow the closed loop shapes printed on the sheet material.

9. A machine according to claim 7, wherein the cutting head is a mirror and laser beam galvo focussing cutting head mounted over the cutting table, including a pair of mirrors capable of pivoting in an oscillating manner about mutually perpendicular pivotal axes to cause a focus point of the laser beam to move in X and Y directions over the surface of the sheet material on the cutting table to follow the closed loop shapes printed on the sheet material.

10. A machine according to any of claims 6 to 9, wherein the cutting table is the top span of a perforated slat conveyor, and air suction through the perforations in the slats serves to draw the sheet material down against the top span of slats to hold it firmly on the cutting table during the cutting out of the closed loop shapes.

11. A machine according to claim 10, wherein the reservoir comprises means for mounting a roll of the sheet material which is a flexible sheet material, means for withdrawing the sheet material from the roll and means for laterally moving the roll to maintain a smooth and unwrinkled presentation of the sheet material to the cutting table as the sheet material is withdrawn from the roll.

Amendments to the claims have been filed as follows

Claims

1. A method of programming and operating a numerically controlled cutting machine to cause it to cut out shapes from a sheet material corresponding to closed path outlines pre-printed on that sheet material, which comprises:

moving the sheet material from a reservoir of pre-printed sheet material in a constant forward direction past one or more cameras or optical sensors and towards a cutting table where the shapes are to be cut;

using the one or more cameras or optical sensors to detect continuous lines pre-printed on the sheet material as it moves from the reservoir towards the cutting table;

processing the continuous line data detected by the one or more cameras or optical sensors as the sheet material moves past the cameras or optical sensors towards the cutting table to identify closed loop shapes printed on the sheet material;

deriving cutting command data from the identified shapes as the sheet material moves further towards the cutting table; and

transferring that derived cutting command data to the cutting machine to cause the machine to cut the identified shapes from the sheet material as it passes over the cutting table, following the continuous lines pre-printed on that sheet material.

2. A method according to claim 1, wherein the data processing step comprises ignoring any closed loop shapes contained within the boundaries of other larger closed loop shapes.

3. A method according to claim 1, wherein the data processing step comprises identifying closed loop shapes even when they are contained within the boundaries of other larger closed loop shapes.

4. A method according to any preceding claim, wherein the sheet material is a flexible sheet material and the reservoir is a roll from which the sheet material is drawn and moved in its constant forward direction towards and over the cutting table.

5. A method according to any preceding claim, wherein the cutting table is a perforated conveyor style moving cutting table and the sheet material is held firmly on the cutting table by air suction as it is cut.

6. A numerically controlled cutting machine, comprising:

means for moving sheet material from a reservoir of pre-printed sheet material in a constant forward direction towards and over a cutting table;

one or more cameras or optical sensors located directly over the sheet material as it passes from the reservoir towards the cutting table;

means for

(a) identifying as continuous line data, from the output of the one or more cameras or optical sensors, continuous lines pre-printed on the sheet material, and

(b) processing the continuous line data to identify closed loop shapes printed on the sheet material, and

(c) deriving cutting command data from the identified shapes;

said means being programmed to complete steps (a) to (c) as the sheet material moves between the one or more cameras or optical sensors to the cutting table; and

means for transferring that derived cutting command data to means for driving a cutting head of the cutting machine to cause the machine to cut the identified shapes from the sheet material as it passes over the cutting table, following the continuous lines pre-printed on that sheet material.

7. A machine according to claim 6, wherein the cutting head is a laser cutting head.

8. A machine according to claim 7, wherein the cutting head is a mirror and laser beam focussing head mounted on a rail over the cutting table so as to be reciprocally slidable in an X direction along that rail, the rail itself being mounted between a pair of rails over the cutting table so as to be reciprocally slidable in a Y direction along those rails, the means for driving the cutting head being effective to cause reciprocal sliding of the cutting head in the X and Y directions in response to the derived cutting command

data to cause the cutting head to follow the closed loop shapes printed on the sheet material.

9. A machine according to claim 7, wherein the cutting head is a laser beam galvo mirror cutting head mounted over the cutting table, including a pair of mirrors capable of pivoting in an oscillating manner about mutually perpendicular pivotal axes, the means for driving the cutting head being effective to cause a focus point of the laser beam to move in X and Y directions over the surface of the sheet material on the cutting table to follow the closed loop shapes printed on the sheet material.

10. A machine according to any of claims 6 to 9, wherein the cutting table is the top span of a perforated slat conveyor, and air suction through the perforations in the slats serves to draw the sheet material down against the top span of slats to hold it firmly on the cutting table during the cutting out of the closed loop shapes.

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11. A machine according to claim 10, wherein the reservoir comprises means for mounting a roll of the sheet material which is a flexible sheet material, means for withdrawing the sheet material from the roll and means for laterally moving the roll to maintain a smooth and unwrinkled presentation of the sheet material to the cutting table as the sheet material is withdrawn from the roll.

Intellectual Property Office

Application No:	GB1904937.8	**Examiner:**	Dr Jamie Frost
Claims searched:	1-11	**Date of search:**	11 July 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-11	https://www.youtube.com/watch?v=Wszt7kY3JSM "Laser Cutting Dye Sublimation - Contour Cut Vision" Published 9th February 2018.
X	1-11	"Laser Cutting Printed Fabrics - Contour Cut Vision" promotional material by CadCam Technology Ltd. Dated to 2016 at the earliest.
X	1-11	https://www.youtube.com/watch?v=ln_Rafksg0c "Laser Cutting Printed Textiles and Fabrics - Contour Cut Vision - Golden Laser", published 20th December 2013.
X	1-11	US 5614115 A (HORTON et al.) see whole document, especially; abstract.
X	1-11	US 9868302 B1 (AMINPOUR) see whole document, especially; abstract.
X	1-11	WO 2019/012566 A1 (MORGAN TECNICA) see whole document, especially; abstract.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

Online Search

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
B23K	0026/03	01/01/2006
B23K	0026/08	01/01/2014
B23K	0026/36	01/01/2014
B26D	0005/00	01/01/2006
B26D	0005/34	01/01/2006
B23K	0101/18	01/01/2006