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- (71) Applicant: **TANNLIN TECHNOLOGY LIMITED**
[GB/GB]; 37 Portland Road, Kilmarnock KA1 2DJ (GB).
- (72) Inventors: **HALL, James Graham**; 9, Southwood Road,
Troon KA10 7EL (GB). **SHAW, Fraser Murray**; 4, Old
Station Wynd, Troon KA10 6RR (GB).
- (74) Agent: **MCKECHNIE, Neil**; Delta House, 50 West Nile
Street, Glasgow G1 2NP (GB).
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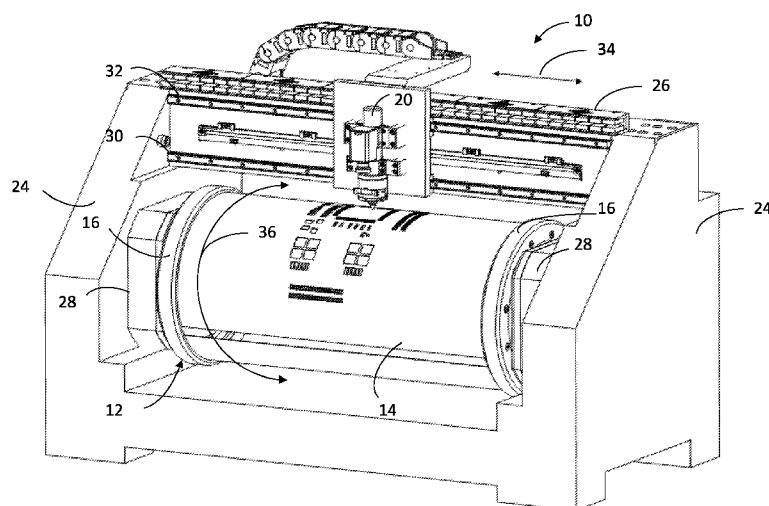


Figure 1

(57) Abstract: A laser cutting machine (10) comprises a laser cutting head (20) movable along a linear axis and a stencil material mount (16), which is configured to rotate about an axis substantially parallel with the linear axis. The stencil material mount (16) is configured to receive stencil material in a substantially cylindrical form.

LASER CUTTING MACHINE

FIELD OF THE INVENTION

The present invention relates to a laser cutting machine. In particular, the present invention relates to a two-axis laser cutting machine, comprising a linear axis and a theta axis.

5 BACKGROUND TO THE INVENTION

Laser cut stencils are in principle no different to any other two-dimensional laser cut part. A pattern comprising holes is retained and the cut-out pieces, forming the holes are discarded. Movement of the laser cutting head is increasingly carried out by linear actuators.

Many different forms of machine, in particular, flat bed cutters are used to achieve the
10 required linear/translational movement of the laser beam through the stencil material.

An example of a conventional stencil cutting machine is a combination axis machine that comprises a stationary cutter and moving axes, generally in two directions. The movement is designed in lower and upper axes. Such a machine is generally heavy and results in offset loads, which means that the acceleration is inconsistent and mechanical response can
15 be irregular depending on the relative axes position.

Another example of a conventional stencil cutting machine is a split axis machine, where the cutter moves along one axis and the stencil material is moved along a second axis. Compared with the combination axis machine the split axis machine demonstrates more uniform loading. However, in view of the movement of the stencil material the scale and size
20 of the split axis machine can be much greater than the combination axis machine because the stencil material can be fed in large sheets, which therefore must be supported and transported during the cutting process.

Movement of the stencil material and the cutter may also present problems during laser cutting because the motion components associated with the moving stencil material may be

affected by laser spatter and as such protection of the motion components, that are generally on the underside of the sheet, is required. Due to the high accuracy required by the cutting process the stencil material needs to be supported and held in tension sufficiently whilst the material is cut to ensure accuracy of the pattern to be cut in the material. As such,
5 often a complex and heavy support arrangement is required for the stencil material which can affect the mechanical response.

A further example of a conventional stencil cutting machine is a gantry design, where the stencil sheet is held stationary and the cutter is supported and movable, relative to the stencil material, with a gantry. In this example, the cutter is arranged to move in both the x
10 and y axes. To achieve the desired movement two or three linear actuators are used.

In the application of precision laser cutting three linear actuators are generally required.

Laser cutting of stencils requires micron accuracy and as such most current laser stencil cutting machines, for example a Tannlin TXPROi laser stencil machine utilises three linear motion stages - each comprising a motor, a linear bearing and a linear scale, with sub-
15 micron linear measurement to form part of a linear actuator control loop. In this particular example motion is defined by X, Y and YY axes. The YY axis acts as a slave to the Y axis to ensure that the entire movement envelope is possible with minimum inaccuracies. The close coupled system, where motion and measurement are as close together as possible minimizes errors in the cutting process.

20 In the production of laser cut stencils, a gantry design needs to achieve high speed and high accuracy and generally has a movement envelope of at least 600mm by 600mm. The stencil material used with the machines is thin, generally less than 0.15mm thick and the tendency, therefore, is easy damage of the material if not sufficiently tensioned. Typically, the material can be frame mounted foil, where the frame tensions the foil [stencil material]
25 for cutting. Alternatively, the machine may comprise an integral/built-in tensioning mechanism operable to apply sufficient tension to the foil. Such an arrangement requires

large scale machine and as such working to sub micron or micron tolerances can be problematic in large scale application, for example due to affects of temperature, errors in pitch, roll and yaw in any or each of the axes, which can vary almost infinitely along the length of each of the axis. In particular, cross coupling errors reduce the bandwidth of gantry design machines. As a result relatively large errors may be induced which would reduce performance of the machine.

It is desirable to provide an improved stencil cutting machine.

It is further desirable to provide a stencil cutting machine that mitigates the problems associated with known stencil cutting machines.

10 **SUMMARY OF THE INVENTION**

The present invention provides a laser cutting machine comprising:

a laser cutting head movable along a linear axis;

a stencil material mount configured to rotate about an axis substantially parallel with the linear axis; wherein the stencil material mount is configured to receive stencil material in a substantially cylindrical form.

The linear axis may be substantially horizontal, an x-axis.

Advantageously, a laser cutting machine according to the present invention operates on a two axis system, where the first axis is linear, for example, an x-axis and the second axis is rotational or angular, also known as a theta axis. As such the resulting laser cutting machine has a smaller footprint than conventional machines and also provides improved ability to achieve, consistently, accurately cut stencils because the number of effective moving axes is reduced. In addition, a laser cutting machine according to the present invention provides a reduced moving mass and reduced alignment and cross coupling errors.

The machine may further comprise a gantry arrangement, comprising substantially vertical support members and a substantially horizontal member, where the horizontal member facilitates the translational linear movement of the laser cutter.

The horizontal member may comprise one or more rails. The laser cutter may be configured
5 to move along the rails. Each rail may be substantially parallel to the rotational axis of the stencil material mount.

The stencil material mount may comprise a rotating member configured to receive stencil material pre-formed as a partial cylinder or a complete cylinder. As such the machine according to the present invention does not require tension and/or sheet supports because a
10 coiled sheet of stencil material becomes strong and stable when it is formed into a cylinder or partial cylinder. The sheet material may be a single or partial coil comprising one or less rotations of sheet material

The stencil material mount may comprise one or more structural members to which stencil material is attachable. In the form of a cylinder or partial cylinder, the stencil material may
15 comprise inherent spring properties, which act to bias the cylinder to a planar sheet form. Therefore, the natural bias provided by the planar sheet being shaped in a cylindrical form means that the sheet will tend to straighten and therefore shall act to force the material outward against a restraining member. The restraining member may be provided as part of the structural member. The restraining member may provide a fixed datum thereby providing
20 a substantially constant radius such that the relative position of the laser cutting head and the stencil material is maintained constant and the linear movement of the laser cutting head relative to the rotary movement of the stencil material is constant and accurate cutting is assured. As such, when the stencil material is removed from the machine and is returned to the normal planar form for use as a printing medium the linear dimensions and
25 arrangement of the laser printed matter will be substantially accurate.

Alternative to the above, the stencil mount may comprise structural members to which a cylindrical frame is attachable, wherein the cylindrical frame includes stencil material. The structural member may comprise a removable clamping device arranged to clamp the cylindrical frame, wherein the stencil material, as described above, is configured in a forced
5 cylindrical form including inherent spring properties. As such, the stencil material may bias towards a restraining edge. Additional means of force to push the material outwards clamping to the restraining means providing the datum edge. The additional means of force may be provided by a bladder.

By limiting the movement of the stencil material to rotation about a single axis and the
10 movement of the cutter to translational movement along a single axis the mechanical response associated with conventional laser machines is improved because the effective moving mass is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention are described below, by way of example only, with
15 reference to the accompanying drawings, in which:

Figure 1 illustrates a schematic representation of a laser cutting machine according to an embodiment of the present invention.

DETAILED DESCRIPTION

Referring to figure 1 an example of a laser stencil cutting machine 10 according to
20 embodiments of the present invention is illustrated. The machine 10 includes a drum arrangement 12, wherein the stencil material (foil) 14 is wound to a cylindrical form and fitted between two support members 16. The support members 16 and the stencil material 14 are arranged to rotate about a horizontal axis, which maintains the stencil material 14 in parallel to the axis of movement of a stencil cutting tool 20. The distance between the cutting tool 20
25 and the stencil material 14 can therefore remain constant during the cutting process.

The machine 10 is a "gantry" design where the cutting tool 20 is located above the stencil material 14.

Referring to figure 1, the machine 10 includes two vertical support members 24 and a horizontal member 26 that spans across the machine 10 above the rotating stencil material 14. The vertical support members 24 also support a mechanism 28 that facilitates rotation of the stencil material 14.

In the illustrated example the horizontal member comprises two rails 30, 32 along which the cutting tool 20 moves. Two rails 30, 32 are provided such that linearity and spacing between the stencil material 14 and the cutting tool 20 remains consistent and the risk of the tool 20 jamming is substantially removed.

The combination of translational movement 34, of the stencil cutting tool 20, and rotational movement 36, of the stencil material 14, provides a laser cutting machine that operates efficiently on two axes, an x-axis and a theta-axis. It will be appreciated that the machine may only require two motors, one linear and one rotary; therefore bandwidth of the axes control is improved compared with known machines. The design may use two rotational actuators requiring less precision than conventional linear actuators, which are generally separated by up to 1 metre and require a very large high precision structure on which to mount the linear actuators. The rotational actuators may have a diameter as little as 250mm and may be mounted on housings as small as 100mm. Therefore, the need for large high precision structures is massively reduced because the rotational actuators may be mounted in micro-adjustable housings to achieve the required accuracy. The laser cutting machine 10 according to embodiments of the present invention provides a machine 10, presenting a large reduction in cross coupling errors compared with conventional designs and therefore presents increased bandwidth of the laser cutting system.

The stencil material 14 is in the form of a cylinder. In the cylindrical form the stencil material 14 is for example loaded into a chuck or clamping device 16 before inserting the material into the machine 10 and locating it between the rotational actuators 28.

The inherent spring properties of the stencil material 14, in a cylindrical form, means that the stencil material 14 will be biased towards its normally planar, straight configuration therefore, when inserted in the chuck the inherent spring force will act to push the material against the clamping device or supporting structure 16.

- 5 An alternative arrangement is where the stencil material 14 includes slots which engage with grooves in the support structure to secure the stencil material in the machine 10.

The cylindrical form of the stencil material 14 and the effective clamping arrangement results in the stencil material forming a uniform radius about the rotational axis. Therefore, the distance between the stencil material 14 and the cutting tool 20 is substantially constant.

- 10 The stencil material 14 may be formed as a complete or partial cylinder comprising one or less turns of material.

The cutting tool 20 is a laser, which may be a conventional fibre delivered/fibre laser. The cutting tool, including the laser and focus optic are arranged to move translationally along a horizontal axis, which is parallel to the rotational axis of the stencil material 14.

- 15 Whilst specific embodiments of the present invention have been described above, it will be appreciated that departures from the described embodiments may still fall within the scope of the present invention.

CLAIMS

1. A laser cutting machine comprising:

a laser cutting head movable along a linear axis;
- 5 a stencil material mount configured to rotate about an axis substantially parallel with the linear axis; wherein the stencil material mount is configured to receive stencil material in a substantially cylindrical form.
2. A laser cutting machine according to claim 1, wherein the linear axis is substantially horizontal, an x-axis.
- 10 3. A laser cutting machine according to claim 1 or 2, further comprising a gantry arrangement, which comprises at least two substantially vertical support members and a substantially horizontal member, wherein the horizontal member facilitates the translational linear movement of the laser cutting head.
4. A laser cutting machine according to claim 3, wherein the horizontal member
15 comprises one or more rails.
5. A laser cutting machine according to claim 4, wherein the laser cutting head is configured to move along the rails.
6. A laser cutting machine according to claim 4 or 5, wherein each rail is substantially parallel to the rotational axis of the stencil material mount.
- 20 7. A laser cutting machine according to any preceding claim, wherein the stencil material mount comprises a rotating member configured to receive stencil material pre-formed as a partial cylinder or a complete cylinder.

8. A laser cutting machine according to any preceding claim, wherein the stencil material mount comprises one or more structural members to which stencil material is attachable.

9. A laser cutting machine according to any preceding claim, further comprising a
5 restraining member, configured such that in use the inherent spring properties of the stencil material act to force the material outward against the restraining member.

10. A laser cutting machine according to claim 9, wherein the restraining member is provided as part of the structural member.

11. A laser cutting machine according to claim 9 or 10, wherein the restraining member
10 provides a fixed datum thereby providing a substantially constant radius such that the relative position of the laser cutting head and the stencil material is maintained constant and the linear movement of the laser cutting head relative to the rotary movement of the stencil material is constant.

12. A laser cutting machine according to claims 1 to 7, wherein the stencil material
15 mount comprises one or more structural members to which a cylindrical frame is attachable, wherein in use the cylindrical frame includes stencil material.

13. A laser cutting machine according to claim 12, wherein the structural members comprise a removable clamping device arranged to clamp the cylindrical frame such that the stencil material is securely held.

20 14. A laser cutting machine according to claim 13, further comprising a restraining member against which the stencil material is clamped, in use.

15. A laser cutting machine according to any of claims 9 to 15, further comprising additional means of force operable to push the stencil material outwards to clamp the material against the restraining member.

16. A laser cutting machine according to claim 15, wherein the additional means of force comprises a bladder.

17. A laser cutting machine as hereinbefore described and with reference to the drawings.

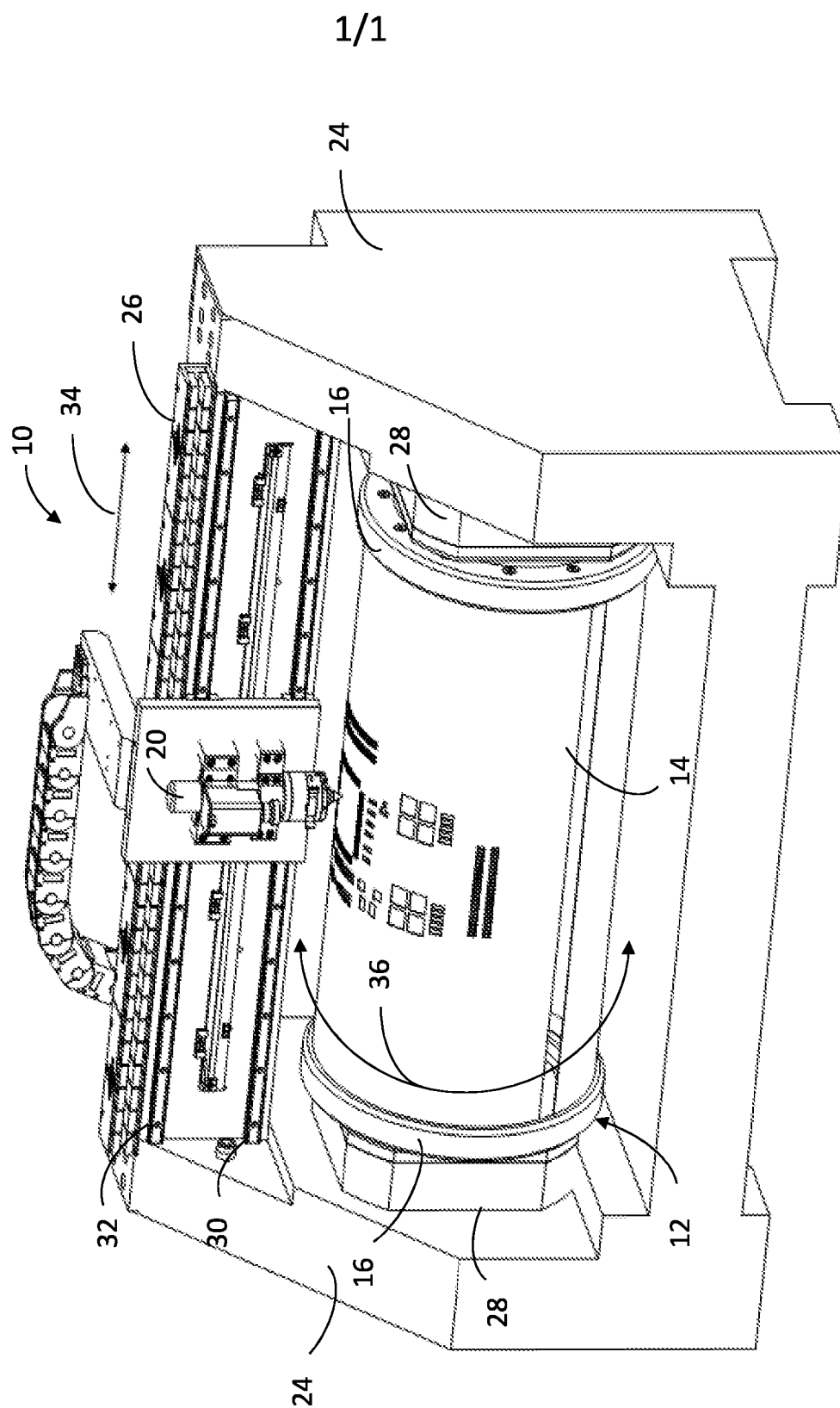


Figure 1

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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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	US 4 806 727 A (RUECKL SIEGFRIED [AT]) 21 February 1989 (1989-02-21) column 2, line 19 - column 3, line 41; figures 1-3	1-17
X	----- EP 1 460 165 A1 (MATEC SPA [IT]) 22 September 2004 (2004-09-22) paragraph [0032] - paragraph [0036]; figures 1-6,8	1-17
X	----- US 2007/125756 A1 (KELLY WILLIAM G [US] ET AL) 7 June 2007 (2007-06-07) paragraph [0043] - paragraph [0060]; figures 1,2,3	1-17



Further documents are listed in the continuation of Box C.



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NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

De Backer, Tom

INTERNATIONAL SEARCH REPORT

Information on patent family members

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