US010569439B2

(12) **United States Patent**
Broeker

(10) **Patent No.: US 10,569,439 B2**
(45) **Date of Patent: Feb. 25, 2020**

(54) **DEVICE FOR PROCESSING OF MATERIALS BY CUTTING AND CUTTING UNIT WITH OSCILLATING CUTTING KNIFE AND VARIABLE CUTTING ANGLE OF INCLINATION**

(71) Applicant: **Guenter Broeker**, Halstenbek (DE)

(72) Inventor: **Guenter Broeker**, Halstenbek (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 159 days.

(21) Appl. No.: **15/633,471**

(22) Filed: **Jun. 26, 2017**

(65) **Prior Publication Data**

US 2017/0305027 A1 Oct. 26, 2017

Related U.S. Application Data

(62) Division of application No. 14/075,797, filed on Nov. 8, 2013, now abandoned.

(30) **Foreign Application Priority Data**

Jun. 3, 2013 (DE) 10 2013 009 251

(51) **Int. Cl.**
B26D 7/01 (2006.01)
B26F 1/38 (2006.01)
B26D 7/26 (2006.01)

(52) **U.S. Cl.**
CPC ***B26D 7/015*** (2013.01); ***B26D 7/2628*** (2013.01); ***B26F 1/3806*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B26D 7/015; B26F 1/3806; B26F 1/3813
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,955,350 A 4/1934 Field
5,150,639 A * 9/1992 Hamamura B26F 1/3813 156/267

(Continued)

FOREIGN PATENT DOCUMENTS

DE 19810333 9/1999
DE 112006003596 11/2008

(Continued)

OTHER PUBLICATIONS

G3 Digital Cutter, Technissche Ubersicht, Oct. 2012, ZUND Swiss Cutting Systems, German Language, 6 pages.

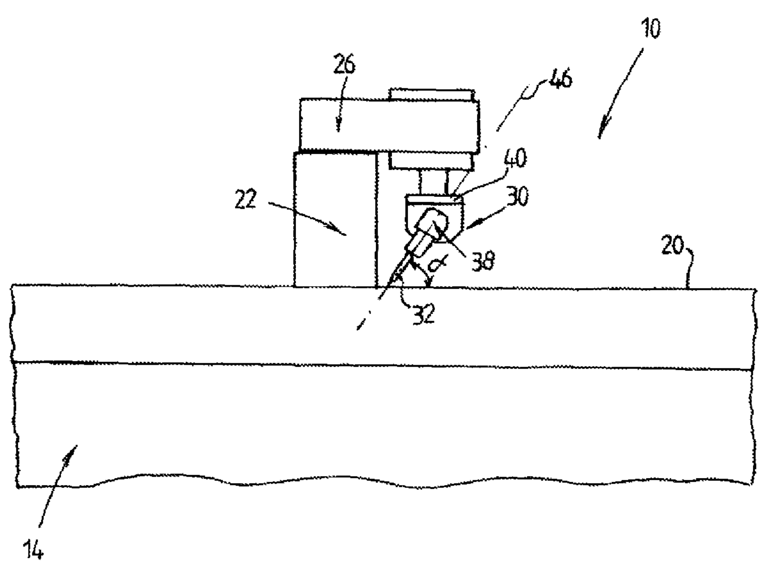
(Continued)

Primary Examiner — Kenneth E Peterson
Assistant Examiner — Liang Dong
(74) *Attorney, Agent, or Firm* — Lempia Summerfield Katz LLC

(57) **ABSTRACT**

A device for the cutting of material on a plane material supporting surface, the device having at least one cutting unit which can be motor-driven in a controlled manner above the material supporting surface in the direction of the X- and Y-axis of a Cartesian coordinate system that is parallel to the material supporting surface, and having an oscillation drive and a cutting knife, wherein the oscillation drive sets the cutting knife into linear oscillations along an oscillation axis that is perpendicular to the advancing direction of the cutting knife. The cutting knife is pivotable around a pivot axis that is parallel to the material supporting surface and is aligned with the rotary axis of a rotary drive shaft of an electric motor of the oscillation drive.

14 Claims, 7 Drawing Sheets



(52) **U.S. Cl.**
CPC ***B26F 1/3813*** (2013.01); *B26D 2007/2678* (2013.01); *B26F 2001/388* (2013.01); *B26F 2001/3886* (2013.01); *Y10T 83/865* (2015.04)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,197,198	A *	3/1993	Onozato	B26F 1/3806	
				33/1 M	
6,131,498	A *	10/2000	Gerber	B26D 1/10	
				30/393	
6,152,003	A *	11/2000	Jung	B26D 7/20	
				83/74	
2009/0084235	A1 *	4/2009	Kata	B26D 5/005	
				83/72	
2009/0266217	A1 *	10/2009	Nonaka	B26D 7/2628	
				83/881	
2011/0166693	A1 *	7/2011	Nishibashi	G05B 19/4103	
				700/187	
2016/0236287	A1 *	8/2016	Tanaka	B26D 1/04	

FOREIGN PATENT DOCUMENTS

DE	102008009843	8/2009
WO	WO2010066054	6/2010

OTHER PUBLICATIONS

G3 Digital Cutter, Technical Overview, Oct. 2012, ZUND Swiss Cutting Systems, Englsih Language, 6 pages.

G3 S3 Digital Cutter, Module, Werkzeuge and Anwendungen, May 2012, ZUND Swiss Cutting Systems, German Language, 8 pages.

Kombo SD; The Right Choice for the Finishing in the Graphic Industry, Product Information, Elitron Innovative Producation Methods, Date Unknown, 3 pages.

Zund Digital Cutters, Modules, tools and applications, Oct. 2013, Zund Swiss Cutting Systems, English language, 8 pages.

* cited by examiner

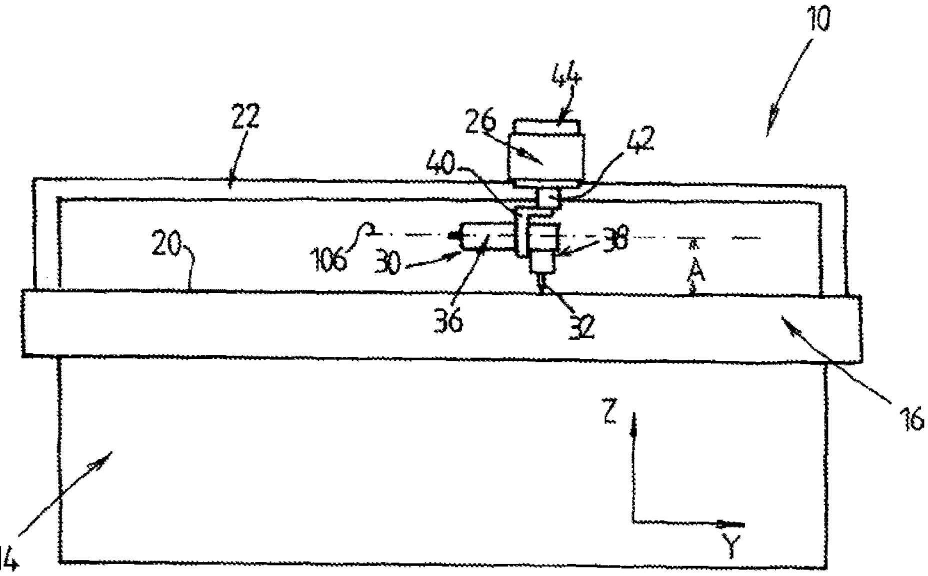

10
44
26
22
42
40
20
106
30
38
A
36
32
16
Z
14
Y

Fig. 1

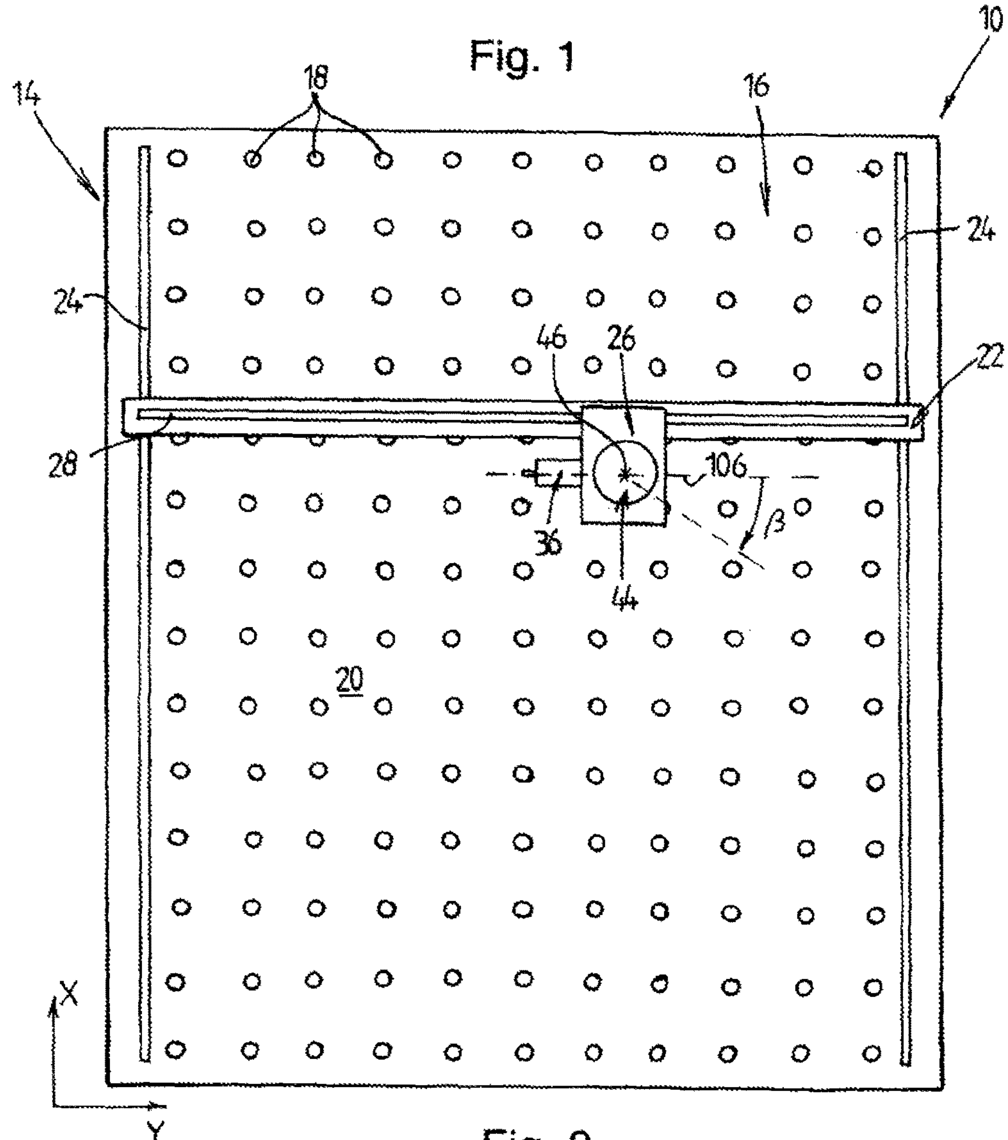

10
18
16
14
24
24
46
26
22
28
106
36
β
44
20
X
Y

Fig. 2

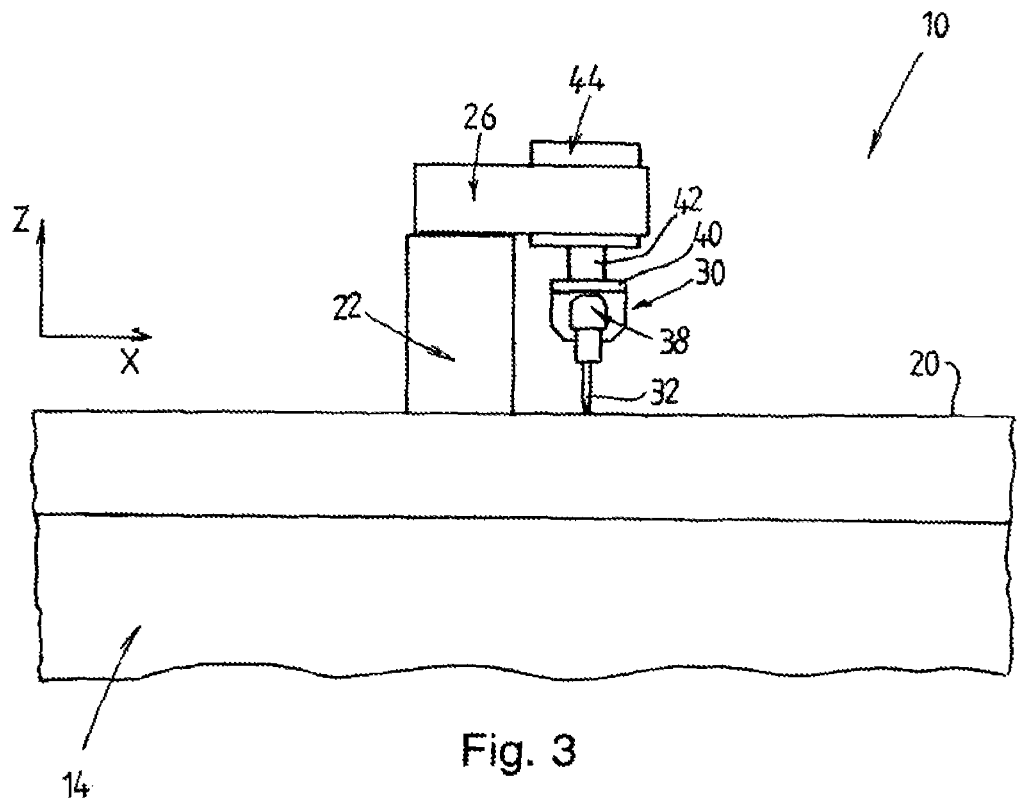


Fig. 3

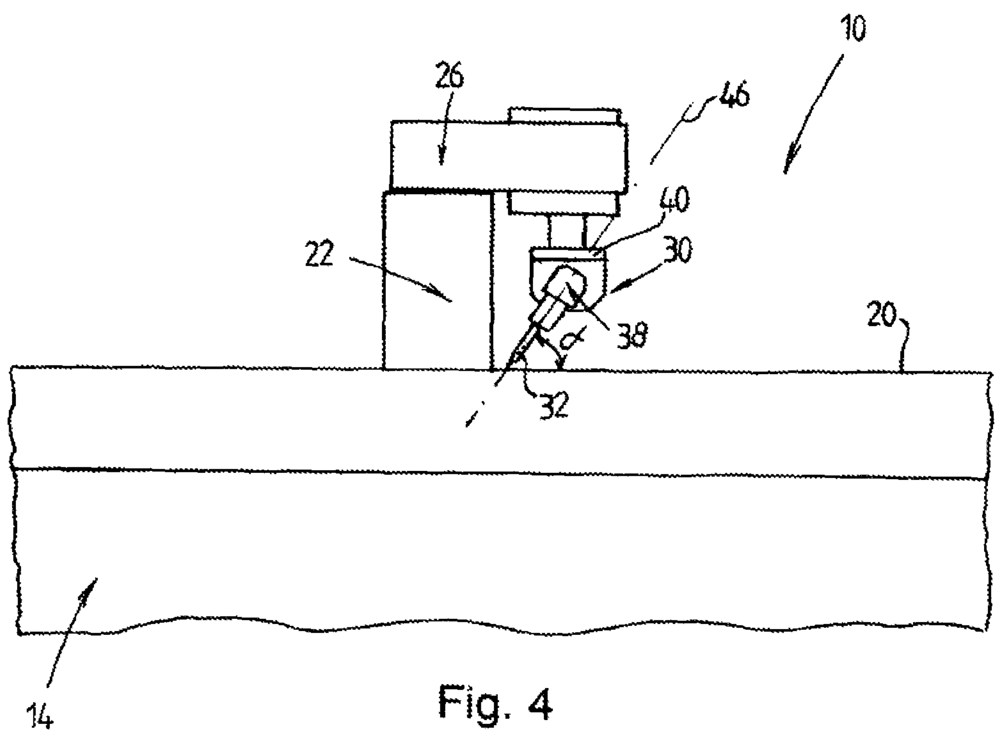


Fig. 4

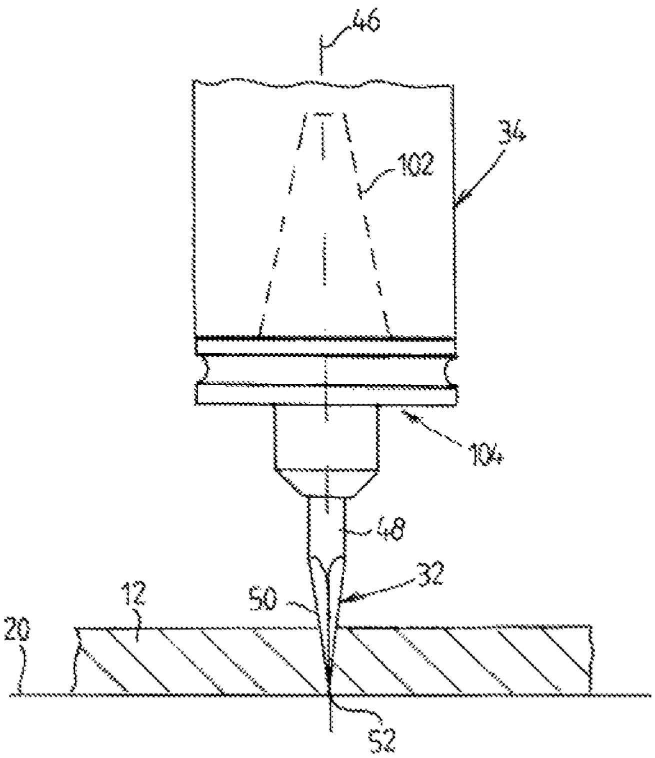


Fig. 5

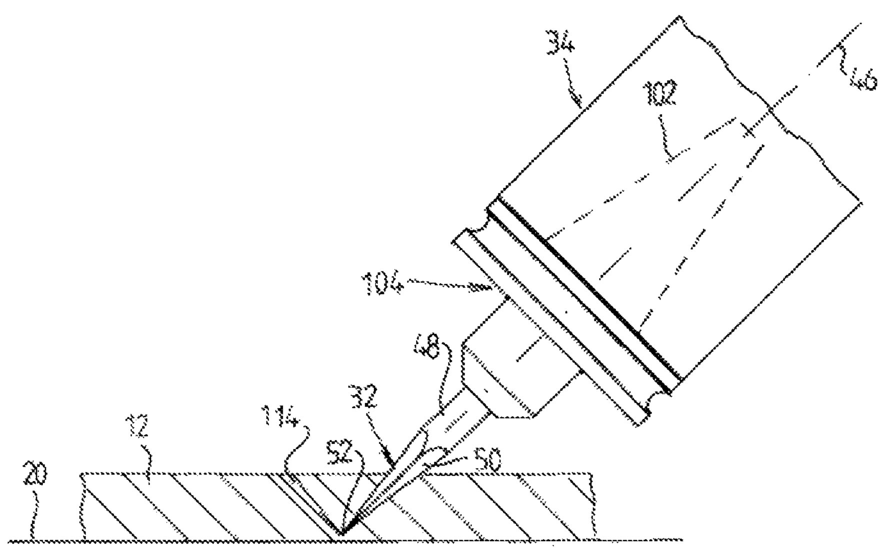


Fig. 6

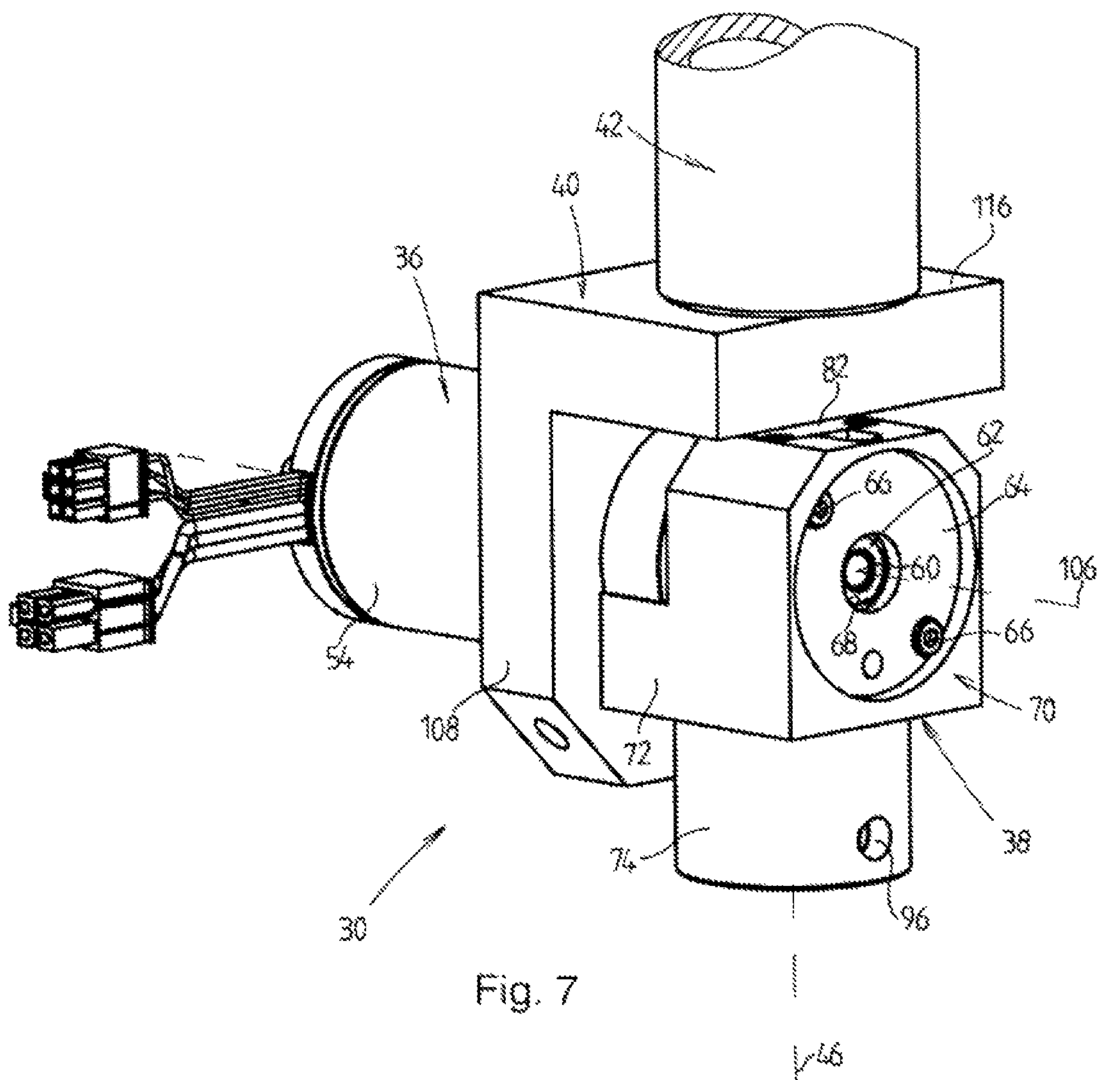


Fig. 7

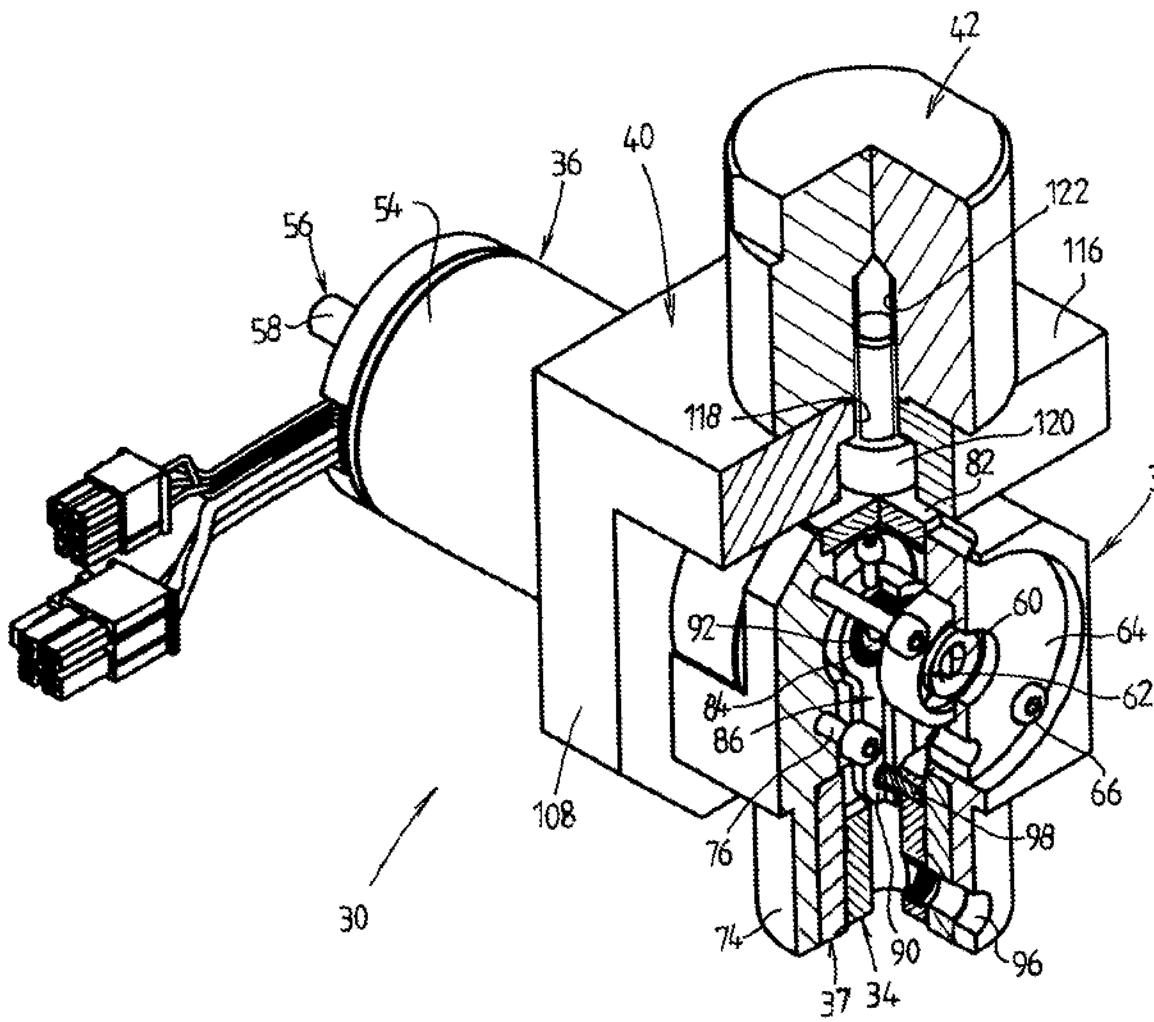

42
36
40
122
116
56
54
58
118
120
82
38
60
92
64
84
62
86
66
76
98
108
74
90
96
30
37
34

Fig. 8

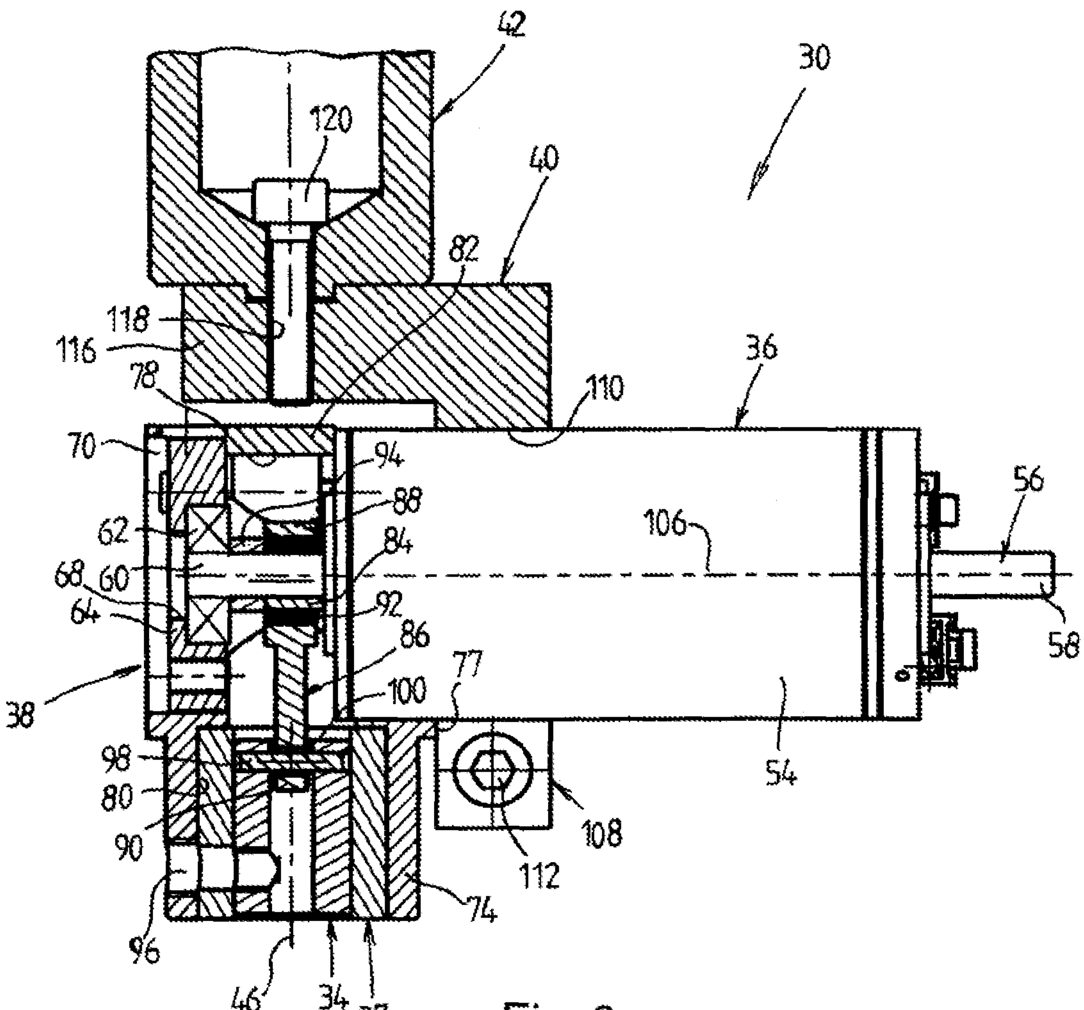

42
30
120
40
82
118
116
36
78
110
70
94
88
62
106
56
84
68
60
92
64
58
86
77
100
38
98
80
90
54
108
112
74
96
46
34
37

Fig. 9

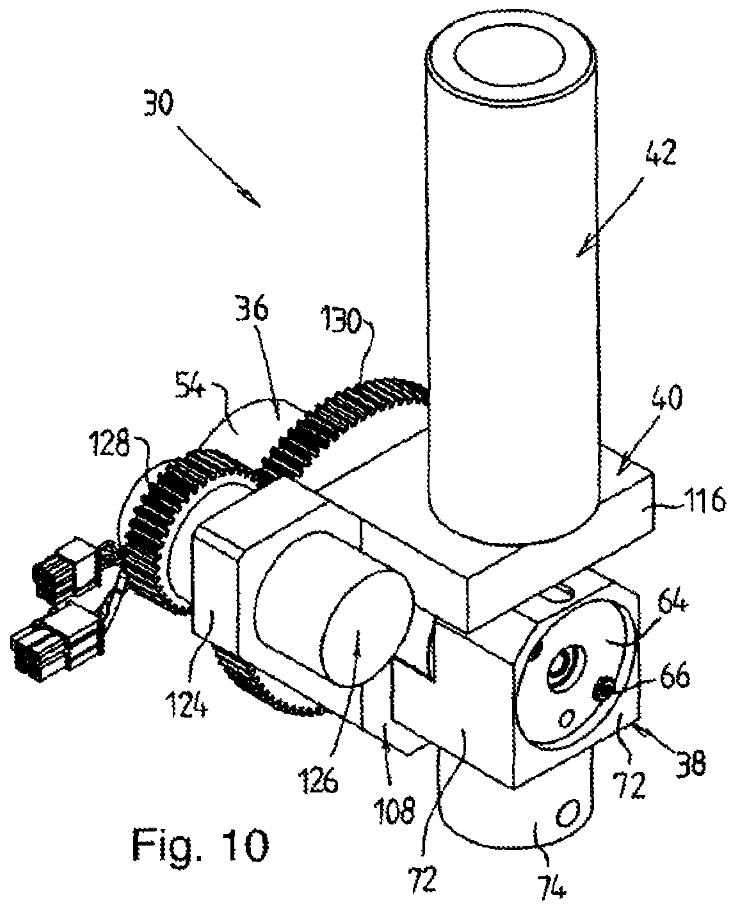

30
42
36
130
54
40
128
116
64
66
124
38
72
126
108
72
74

Fig. 10

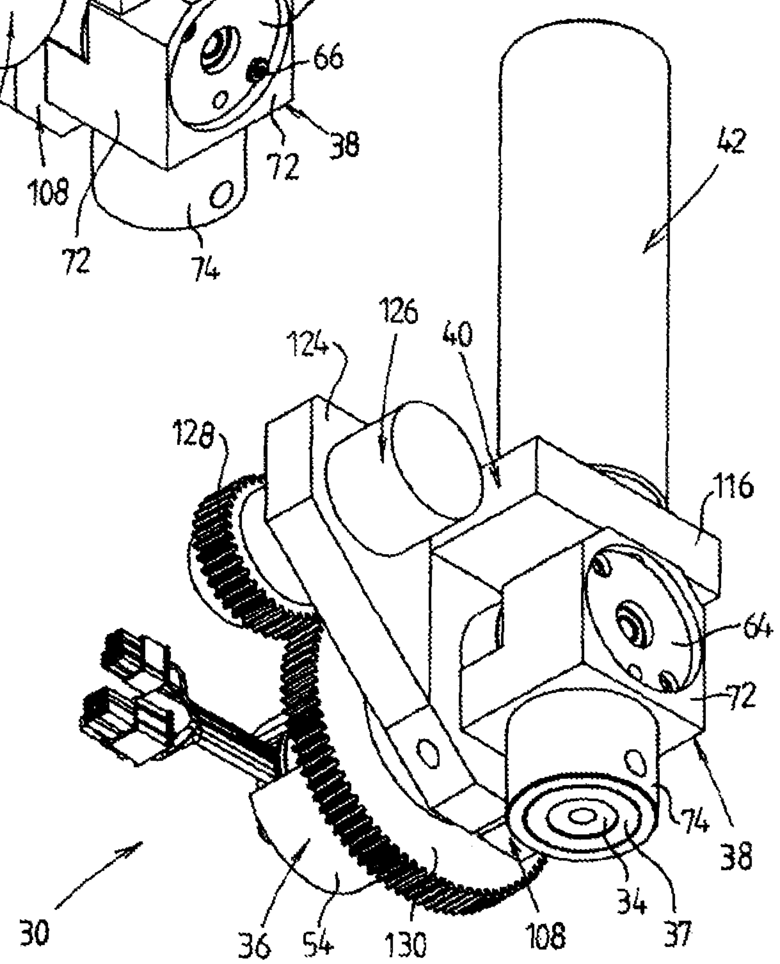

42
126
124
40
128
116
64
72
74
38
30
34
37
36
54
130
108

Fig. 11

DEVICE FOR PROCESSING OF MATERIALS BY CUTTING AND CUTTING UNIT WITH OSCILLATING CUTTING KNIFE AND VARIABLE CUTTING ANGLE OF INCLINATION

RELATED APPLICATION DATA

This patent is a division of and claims priority benefit of co-pending U.S. application Ser. No. 14/075,797 filed Nov. 8, 2013 and of the same title, and which claimed priority to German national application no. 10 2013 009 251.5 filed Jun. 3, 2013. The entire contents of this prior filed application are hereby incorporated herein by reference.

FIELD OF THE DISCLOSURE

The present invention relates generally to devices for cutting materials, and more particularly to a device for cutting material on a material supporting surface and to a cutting unit with an oscillation drive, a holder for the oscillation drive, and a cutting knife, wherein the oscillation drive sets the cutting knife into linear oscillations along an axis of oscillation that is perpendicular to an advancing direction of the cutting knife.

BACKGROUND

Devices of the type named above are used for the cutting of cuttable material, especially of web-like or sheet-like material, for example, films, cloth, paper, cardboard, foamed material or polystyrene. Such devices are disclosed among others in the pamphlet "Technical Overview of the Digital Cutter G3" of the company Zünd Systemtechnik AG and in the pamphlet "Kombo SD" of the company Eiltron. The material supporting surface of these devices is formed by the plane upper surface of a cutting table, onto which the material to be cut is attached by aspiration using vacuum. Usually the cutting table comprises a motor-driven arch or portal which can be moved in a controlled manner perpendicularly to its longitudinal axis in the direction of the X-axis along the material supporting surface, and a motor-driven carrier on the arch or portal, which can be moved in a controlled manner in the direction of the Y-axis to travel along the arch or portal. On the carrier, one or several holders are attached for replaceable processing units or modules that can be positioned by computer-controlled drive movements of the arch and of the carrier at arbitrary locations above the material on the material supporting surface and which allow arbitrary movement paths across the material. These devices are also called cutting plotters.

As is described in the pamphlet "Kombo SD" of the company Eiltron or in the pamphlet "Modules, Tools and Applications G3 S3 Digital Cutter" of the company Zünd, in addition to milling or marking modules, the processing modules comprise a number of cutting modules or cutting units, which have either fixed cutting knives or oscillating cutting knives and may be provided with a holder for securing them to the carrier.

The cutting modules or cutting units with fixed cutting knives comprise not only those in which the cutting knife is perpendicular to the material support surface but also those in which the cutting knife is inclined in a plane that is perpendicular to its forward moving direction at an angle of 45 degrees, such as the "Passepartout Tool PPT" of the company Zünd, so that the material can be cut at a slant in the direction of movement of the knife, for example, in order to produce a V groove.

The possibility of cutting slanting cuts or V grooves is advantageous, especially in the case of large material thicknesses. However, fairly solid materials, for example, cardboard, cannot be cut with a fixed knife, when the cutting depth exceeds a certain value. Even when the material can still be cut with a fixed knife, the cutting performance is considerably less effective than in the case of cutting units with oscillating cutting knives which are set into oscillation with the aid of an electrical or pneumatic oscillation drive along an axis that is perpendicular to the advancing direction of the cutting knife.

The known electrical oscillation drives are mostly piezoelectric oscillation drives, which have a very small stroke height so that the cutting units equipped with them are not suitable for the cutting of all materials. Cutting units with pneumatic oscillation drives do not provide an exact setting of the cutting depth and require an additional compressed air supply, as a result of which the device becomes more complex and expensive.

Also, to date no cutting units with tangential knives are known with which slanted cuts can be made into the material along a movement path that is curved with respect to the material supporting surface.

SUMMARY

The present disclosure relates to a device for cutting material on a material supporting surface, the device having at least one cutting unit which can be motor-driven in a controlled manner above and across the material supporting surface in the direction of an X-axis and a Y-axis of a Cartesian coordinate system that is parallel to the material supporting surface and which device comprises an oscillation drive and a cutting knife, wherein the oscillation drive sets the cutting knife into linear oscillations having an oscillating axis which is perpendicular to an advancing direction of the cutting knife. Furthermore, the invention relates to a cutting unit comprising an oscillation drive, a holder for the oscillation drive and a cutting knife, wherein the oscillation drive sets the cutting knife into linear oscillations along an axis of oscillation that is perpendicular to an advancing direction of the cutting knife.

Based on the foregoing background, the invention has as its object the improvement of a device and a cutting unit of the type mentioned at the outset so that with the oscillating cutting knife, slanted cuts or V-shaped grooves with a variable angle of inclination with respect to the material supporting surface can be cut into the material.

In the device according to the invention, this object is achieved by the fact that the oscillation drive together with the cutting knife, is pivotable around a pivot axis that is parallel to the material supporting surface in order to alter the angle of inclination of the oscillation axis and thus of the cuts produced in the material with respect to the material supporting surface or in order to set a desired angle of inclination with respect to the material supporting surface. The cutting unit according to the invention is characterized by the fact that the oscillation drive, together with the cutting knife, is pivotable with the respect to the holder around a pivot axis that is perpendicular to the oscillation axis.

The pivot axis of the cutting unit is preferably oriented perpendicularly to the oscillation axis of the cutting knife, so that it intersects the pivot axis at a right angle.

The oscillation drive is preferably an electrical drive, so that an exact cutting depth can be provided and the device does not need an additional compressed air supply, which makes it possible to incorporate the cutting unit even in smaller and more economical devices. Advantageously, the oscillation drive comprises an electrical drive motor with a rotating drive shaft which is connected to a knife holder that carries and guides the cutting knife linearly by means of a cam that converts the rotation of the drive shaft into an oscillating movement of the knife holder. As a result of this, an oscillating movement of the cutting knife is achieved with a stroke height of up to 2 mm, which is more than the stroke height of piezoelectric oscillation drives.

According to a preferred embodiment of the invention, the drive shaft of the oscillation drive is oriented parallel to the supporting surface, wherein its axis of rotation is aligned with the pivot axis. In order to reduce the number of movable parts and thus undesirable vibrations, the drive shaft is advantageously the motor shaft of the electrical drive motor which projects from one side of a motor housing of the drive motor. The motor shaft is supported in the usual manner within the motor housing in two bearings, however, according to a favorable embodiment of the invention, outside the motor housing and beyond the oscillation axis of the cutting knife an additional bearing is provided, in which the free end of the motor shaft is supported rotatably. The additional bearing is expediently removable.

Another preferred embodiment of the device according to the invention provides that the cutting unit is attached to a holder that can be moved in a controlled motor-driven manner in the direction of the X-axis and the Y-axis, wherein the entire cutting unit is secured or suspended replaceably, as expedient, on the carrier.

Since the distance of the tip of the cutting knife from the material supporting surface changes when the oscillation drive with the cutting knife is pivoted around the pivot axis, advantageously the height of the cutting unit with respect to the carrier can be adjusted.

The cutting knife can be fundamentally a drag knife, the cutting edge of which is directed into the advancing direction by frictional forces between the cutting knife and the material. However, preferably, the cutting knife is a tangential knife whose orientation is controlled actively during cutting so that the cutting edge is always positioned in the advancing direction. This control or alignment, which is also called tangential control or tangential feed, is performed according to another preferred embodiment of the invention with the aid of a controlled tangential or rotary drive that is arranged between the oscillation drive and the carrier. With the aid of this tangential or rotary drive the oscillation drive, together with the cutting knife, can be rotated around the oscillation axis of the cutting knife with respect to the carrier. It is thereby possible to cut the material with inclined cuts along curved movement paths.

Preferably, the cutting unit comprises a holder for the oscillation drive in which the latter is supported pivotably, so that, together with the cutting knife, a knife carrier that holds the cutting knife and a guide for the knife carrier, it can be pivoted around the pivot axis with respect to the holder to change the angle of inclination of the oscillation axis with respect to the material supporting surface.

Depending on whether the knife is a drag knife or a tangential knife driven by a tangential or rotary drive, the holder is secured either directly to the carrier or to a drive shaft of the tangential or rotary drive.

Another preferred embodiment of the invention provides that the cutting knife is secured to a linearly guided oscillating knife carrier and that a cam for converting the rotary movement of the drive shaft of the electric motor into an oscillating movement of the cutting knife comprises an eccentric ring and connecting rod drive between the drive shaft and the knife carrier. This eccentric ring and connecting rod drive comprises advantageously an eccentric ring which is fixedly attached to the drive shaft, and a connecting rod the connecting rod foot of which is pivotably hinged or articulated to the knife carrier, whereas its connecting rod head surrounds the eccentric ring. Advantageously, a roller bearing is arranged between the rotating eccentric ring and the connecting rod head. Expediently, a hard metal liner is inserted into the connecting rod foot through which a hard metal bolt extends that is connected to the knife carrier.

In order to ensure that the angle of inclination of the cutting knife can be adjusted to a desired value and does not change during the cutting, advantageously, the oscillation drive can be blocked in various arbitrary and discrete pivot positions, wherein the change of the angle of inclination can be carried out either continuously or in discrete steps. In the first case, the oscillation drive can advantageously be attached to the holder in a fixed manner using a clamping device of the cutting unit, which provides for an arbitrary change of the angle of inclination.

Another preferred embodiment of the invention provides that the angle of inclination of the cutting knife can be altered even during the advancing movement of the knife across the material support surface. Advantageously, this is done with the aid of a computer-controlled actuating drive, which is expediently attached in a fixed manner to the holder and moves the oscillation drive with respect to the holder in a controlled manner around the pivot axis.

By pivoting of the oscillation drive around the pivot axis, the tip of the cutting knife does not only move in the direction of the Z-axis of the Cartesian coordinate system of the material support surface, either away from it or towards it, but also in the direction of the X-axis and, in the case of a rotation of the cutting knife around the rotary axis of the tangential or rotary drive, also moves in the direction of the Y-axis away from the desired movement path. Therefore, another advantageous embodiment of the invention provides that the device has means for compensation of these movements in the direction of the X-, Y- and Z-axes.

To compensate for the movement in the direction of the Z-axis, in the first a.m. case the holder and in the last a.m. case the tangential or rotary drive can be adjusted in height with reference to the carrier so that a change of the position of the tip of the cutting knife as a result of the pivoting movement can be compensated. Expediently, the compensation is carried out automatically as a function of the particular pivoting angle using a computer-controlled actuating drive.

On the other hand, the compensation of the movement of the tip of the cutting knife in the direction of the X- or Y-axis, which is caused by the pivoting of the oscillation drive, is achieved preferably by an appropriate control of a drive of the arch or of the carrier respectively in order to move the arch or the carrier respectively for compensation by a corresponding amount into the opposite direction.

In the following the invention will be explained in more detail with the aid of a practical example shown in the drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a schematic side view of a device according to the invention having a cutting table with a material supporting surface and a cutting unit with a pivotable oscillation drive as well as a cutting knife;

FIG. **2** shows a top view of the device from FIG. **1**;

FIG. **3** shows a slightly enlarged and partially cut-away side view of the device in the direction of the arrows III in FIG. **2** in a state in which the cutting knife is oriented perpendicularly to the material supporting surface;

FIG. **4** shows a view according FIG. **3**, but in a state in which the cutting knife is inclined at an acute angle to the material supporting surface;

FIG. **5** shows an enlarged view of the cutting knife during the cutting of a plate-shaped material and viewed in the advancing direction, in the state according to FIG. **3**;

FIG. **6** shows an enlarged view of the cutting knife according to FIG. **5**, but in the state according to FIG. **4**;

FIG. **7** shows an enlarged perspective view of parts of the cutting unit;

FIG. **8** shows another partially cut-away enlarged perspective view of parts of the cutting unit;

FIG. **9** shows an enlarged cut-away view of parts of the cutting unit;

FIG. **10** shows a perspective view of parts of another somewhat modified cutting unit.

FIG. **11** shows another perspective view of the parts of the cutting unit from FIG. **10**.

DETAILED DESCRIPTION OF THE DISCLOSURE

The device **10** shown in the drawing serves for the processing of material **12** by cutting, especially of layered material or plate-shaped material which has at least one plane surface for laying onto a flat support and which can be cut by a cutting knife, like cardboard, cork, foamed material, polystyrene, reboard or other sandwich slabs.

As shown best in FIGS. **1** and **2**, the device **10** comprises a supporting or cutting table **14** with a table top **16**, whose flat horizontal upper surface forms a material supporting surface **20** for the material to be cut **12**. In order to secure the material **12** on the material supporting surface **20** while it is being cut, the table top **16** is provided with a multiple number of small through-bores **18** which communicate with a plenum (not shown) arranged on the bottom side of the table top **16** from which plenum air is aspirated in order to apply a vacuum to the bores **18**.

Furthermore, the device **10** has an arch or portal **22** which extends in a vertical distance from the material supporting surface **20** across the supporting or cutting table **14** and can be moved back and forth by a controllable portal drive (not shown) on tracks **24** or other linear guides in the direction of a horizontal X-axis of a Cartesian coordinate system that is parallel to the material supporting surface **20**. The arch or portal **22** supports a carrier **26** for a cutting unit **30**, which can be moved back and forth by a controllable carrier drive (not shown) on tracks **28** or other linear guides in the direction of a horizontal Y-axis of the Cartesian coordinate system. The cutting unit **30** can be removed from the carrier **26** so that in case of need it can be replaced by another processing unit, for example, a milling unit or marking unit.

The cutting unit **30** comprises a cutting knife **32**, a knife holder **34**, a linear guide **37** for the knife holder **34**, an oscillation drive **36** for driving the knife holder **34** in an oscillating manner, a cam **38** arranged between the oscillation drive **36** and the knife holder **34**, a tangential or rotary drive **44** for active alignment of the cutting knife **32**, and a holder **40** that connects the oscillation drive to a drive shaft **42** of the tangential or rotary drive **44**.

With the aid of the oscillation drive **36** and of the cam **38**, the cutting knife **32** can be set into linear oscillations, the oscillation axis **46** of which is perpendicular to the advancing direction of the cutting knife **32**, that is, the direction in which the cutting knife **32** moves across the material supporting surface **20** through the material **12** to be cut. When the cutting knife **32** cuts the material **12** along a cutting plane that is perpendicular to the material supporting surface **20**, as represented in FIG. **5**, the oscillation axis **46** of the linear oscillations of the cutting knife **32** is also perpendicular to the material supporting surface **20** and thus coincides with a vertical Z-axis of the Cartesian coordinate system of the device **10**.

As shown best in FIGS. **5** and **6**, the cutting knife **32** has a cylindrical shaft **48** and a narrowed end section **50** which enters into the material **12** to be cut. The cutting knife has a blade or cutting edge pointing in the advancing direction and has a tip **52**. The cutting knife **32** in the drawings is a tangential knife which, during the cutting of material **12** along a curved cutting line, is rotated actively or in a controlled manner around the oscillation axis **46** so that the cut is always aligned with the advancing direction of the knife or is oriented tangentially to the curved cutting line.

The oscillation drive **36** comprises an electric drive motor with a cylindrical motor housing **54** and a motor shaft **56** that is supported within the motor housing **54** in two roller bearings (not visible). The motor shaft **56** comprises two shaft ends **58**, **60**, each of which projects from one of the two opposite ends of the motor housing **54**. The shaft end **60** on the side of the cam **38** is supported with its free end in another roller bearing **62**, so that the motor shaft **56** is rotatably supported in a total of three roller bearings. The roller bearing **62** is inserted into a recess that is coaxial to the rotary axis of the motor shaft **56** the recess being arranged in a removable bearing cover **64**, which is fastened tightly with set screws **66** to the adjacent end of the motor housing **54**. The roller bearing **62** can be lubricated through a bore **68** in the middle of the bearing cover **64**.

The cam **38** has a cam housing **70**, which consists of an upper part **72** arranged in extension of the motor housing **54** and a lower part **74** that protrudes downwardly. Both parts are connected to each other to form one piece. The cam housing **70** is fastened with set screws **76** to the adjacent end of the motor housing **54**. The upper part **72** of the cam housing **70** is arranged between the end of the motor housing **54** and the bearing cover **64**, where it partly overlaps a lower part of the end of the motor housing **54** and abuts the holder **40** with an abutment face **77** on the motor side. The upper part **72** surrounds a stepped bore **78**, which is coaxial with the motor shaft **56**, which extends to the adjacent end of the motor housing **54** and which is closed on its end facing away from the motor housing **54** by the bearing cover **64**. The lower part **74** of the cam housing **70** surrounds a stepped bore **80**, which is open toward the bottom and which is coaxial with the oscillation axis **46**. The lower part **74** opens into the stepped bore **78** within the upper part **72** and is closed at its upper end above the motor shaft **56** by a plate **82**.

The cam **38** is a crank mechanism for converting the rotation of the motor shaft **56** into an oscillating movement of the knife holder **34** along the oscillation axis **46**. Within the cam housing **70** the cam **38** comprises an eccentric ring **84** that is arranged on the shaft end **60** between the adjacent end of the motor housing **54** and the bearing cover **64** in extension of the oscillation axis **46**. The eccentric ring **84** has an inner cylindrical surface that is concentric to the rotational axis of the motor shaft **56** and an outer cylindrical surface that is eccentric to the rotational axis of the motor shaft **56**. The eccentric ring **84** is fixedly attached to the motor shaft **56** so that it rotates together with the motor shaft **56**.

Furthermore, the cam **38** comprises a connecting rod **86** which is made in one piece from light metal. The connecting rod **86** has a connecting rod head **88** surrounding the eccentric ring **84** and a connecting rod foot **90** which is articulated to the knife holder **34**. Between the connecting rod head **88** and the eccentric ring **84** there is a closed needle bearing or ball bearing **92**, the inner ring of which is pressed onto the cylindrical outer peripheral surface of the eccentric ring **84** whereas the outer ring is pressed into an eye of the connecting rod head **88**. In order to accommodate the needle bearing or ball bearing **92**, the width of the connecting rod head **88** is larger than that of the rest of the connecting rod **86** and of the connecting rod foot **90** in the axial direction of the motor shaft **56**, as shown best in FIG. **9**. In order to prevent an axial shift of the eccentric ring **84** and/or of the needle bearing or ball bearing **92**, a spacer **94** is provided on the motor shaft **56** between the eccentric ring **84** and the needle bearing or ball bearing **92** on the one hand and the roller bearing **62** on the other hand.

The knife guide **37** consists of a cylindrical tube that is open at both ends, which is coaxial to the oscillation axis **46** and is inserted from below into a widened part of the stepped bore **80** and fixedly attached.

The knife holder **34** is a hollow cylindrical piston made of light metal, which is guided within the hollow cylindrical knife guide **37** so that it can move in the direction of the oscillation axis **46**, wherein its outer peripheral surface slides during the oscillation movement with a slight clearance on the inner peripheral surface of the knife guide **37**. For lubrication of these sliding surfaces a transverse bore **96** is provided, which extends through a wall of the lower part **74** of the cam housing **70**, a wall of the hollow cylindrical knife guide **37** and a wall of the hollow cylindrical knife holder **34**.

The knife holder **34** is provided on its open upper end with a transverse bore which is perpendicular to the oscillation axis **46**. A holding bolt **98** made of hard metal is pressed into the transverse bore. The bolt **98** extends through a hard metal sleeve **100** in the connecting rod foot **90** of the connecting rod **86**, which protrudes from above through the hollow cylindrical knife guide **37** a little distance into the open upper end of the knife holder **34**.

As shown in FIGS. **5** and **6**, the knife holder **34** has on its lower end a Weldon chuck with a conical clamping surface **102**. With the aid of this chuck a Weldon holder **104** equipped with the cutting knife **32** can be clamped in the knife holder **34** and aligned with respect to the oscillation axis **46**.

In order to facilitate the introduction of cuts into the material **12**, where the cuts have a cutting face that is inclined with respect to the material supporting surface **20** at an acute angle, for example, 45 degrees or 60 degrees, the oscillation drive **36**, together with the cam **38**, the knife guide **37**, the knife carrier **34** and the knife **32** can be pivoted with respect to the holder **40** around a pivot axis **106** that is parallel to the material supporting surface **20**. The pivot axis **106** is aligned with the rotary axis of the motor shaft **56** and is perpendicular to the oscillation axis **46** of the cutting knife **32**. In order to set a desired angle of inclination of the oscillation axis **46** of the cutting knife **32**, additionally the oscillation drive **36** together with the components **32**, **34**, **36** and **38** can be positioned at any desired angular position with respect to the holder **40**.

In the case of the cutting unit **30** in FIGS. **7** to **9**, the pivoting of the oscillation drive **36** and of the components **32**, **34**, **36** and **38** as well as the blocking or clamping of these components in a desired pivoting position is carried out manually. For this purpose, the holder **40**, which is made in one piece, comprises a divided clamping ring **108** in which the motor housing **54** can be clamped tightly. The clamping ring **108** surrounds a through-opening **110**, which has a circular cross-section and an inner diameter that is slightly larger than the outer diameter of the motor housing **54**. The clamping ring **108** consists of two peripheral sections separated by a gap (which cannot be seen), the opposing ends of which sections can be pulled together with the aid of a clamping screw **112** (FIG. **9**), in order to clamp a part of the cylindrical motor housing **56** of the oscillation drive **36** that is adjacent the cam **38** in the through-opening **110** in a rotational position, in which the oscillation axis **46** of the cutting knife **32** has the desired angle of inclination with respect to the material supporting surface **20**. In order to mount and dismount the oscillation drive **36** in the holder **40** as well as to change the angle of inclination of the cutting knife **32**, the clamping screw **112** is loosened just enough so that the motor housing **54** can be shifted in the axial direction into the through-opening **110** or pulled out from this or can be rotated around the pivot axis **106** in the through-opening **110** respectively.

In the cutting unit **30** in FIGS. **10 and 11**, the pivoting of the oscillation drive **36** and of the components **32**, **34**, **36** and **38** as well as the blocking of these components in a desired rotational position can be done with a motor.

For this purpose, the holder **40** comprises a plate-shaped projection **124** protruding sideways above the clamping ring **108** into which a step motor **126** is inserted so that it cannot rotate. The step motor **126** drives a pinion **128** which engages with a toothed-ring **130**. The toothed ring is attached to the motor housing **54** so that it cannot rotate with respect to the motor housing **54** and is coaxial with the pivot axis **106**. In order to set a desired angle of inclination of the oscillation axis **46**, the step motor **26** can be driven in a controlled manner after the set screw **112** has been loosened in order to rotate the motor housing **54** in the through-opening **110** until the desired angle of inclination is reached.

When the angle of inclination of the cutting knife **32** is to be altered during a cutting operation, the clamping ring **108** remains loosened in order to be able to rotate the motor housing **54** by means of the step motor **126**. On the other hand, when the cutting is to be performed with a constant angle of inclination, the set screw **112** is preferably tightened in order to reduce vibrations.

Fundamentally, the oscillation drive **36** can be turned through 360° in the through-opening **110** of the clamping ring **118** with respect to the holder **40**; however, for the processing of the material **12** on the supporting surface **20**, generally it is sufficient when the cutting knife **32**, starting out from the state in FIG. **5**, in which its oscillation axis **46** is perpendicular to the material supporting surface **20**, can be turned through 45° to 60° in the clockwise and counterclockwise directions.

As a result of the pivotability of the oscillation drive **36** and of the cam **38** with respect to the holder **40**, it becomes possible to provide a plate-shaped material **12** resting on the material supporting surface **20**, for example, a reboard plate or a cardboard piece, with cuts **114**, which are inclined with respect to the material supporting surface **20**, as shown in FIG. **6**. In the advancing direction of the cutting knife **32**, the cuts **114** can have either a straight or curved form, so that, in the latter case, for example, a part of a truncated cone shape can be cut out from the plate-shaped material **12**.

When two cuts **114** with opposite inclinations are made into the plate-shaped material **12**, such that the lower ends of the cuts **114** come into contact somewhat above than the supporting surface **20**, a groove that is open towards the top and has a V-shaped cross section can be cut out of the material **12**. When the groove is straight, it is possible to tilt the parts of the plate-shaped material **12** around the base of the groove, until the surfaces of the groove abut each other. After that the two parts are inclined with respect to each other at an angle that corresponds to the opening angle of the groove cross section.

As shown best in FIGS. **7** to **11**, the holder **40** has a plate-like projecting part **116**, which projects above the uppermost part of the clamping ring **108** in parallel to the motor shaft **56**. The projecting part **116** extends at a distance above the cam **38**, so that it does not hinder the pivoting of the cam **38** around the pivot axis **106**. The projecting part **116** is provided with a through-bore **118** that is coaxial with the oscillation axis of cutting knife **32** and serves for receiving a fastening screw **120**. With the fastening screw **120**, the holder **40** can be fixed to the drive shaft **42** of the tangential or rotary drive **44**, so that the holder **40**, together with the oscillation drive **36**, the cam **38** and the tangential knife **32** can be turned by the tangential or rotary drive **44** under control of a computer around the oscillation axis **46**, in order to actively orient the cutting edge **52** of the cutting knife **32** into the advancing direction.

The holder **40** can be screwed onto the drive shaft **42** from below, as shown in FIG. **8**, or from above, as shown in FIG. **9**. In the former case, the through-bore **118** has a lower part that has a larger diameter to hold the head of the fastening screw **120** and an upper part with a smaller diameter for holding the shaft of the fastening screw **120**, which is screwed with its outer thread into an axial blind bore **122** of the drive shaft **42**. In the latter case, the through-bore **118** of the plate-like projection **116** is provided with an inner thread, into which the outer thread of the fastening screw **120** is screwed through an axial through-bore in the closed end of the hollow drive shaft **42**.

When the oscillation drive **36** is pivoted together with the cam **38**, the knife holder **34** and the cutting knife **32** around the pivot axis **106**, the distance between the tip **52** of the cutting knife **32** and the material supporting surface **20** will change. Furthermore, due the pivoting of the oscillation drive **36** and of the components **32**, **34**, **36** and **38** the tip **52** of the cutting knife **32** will deviate from the programmed movement path, which the tip **52** would follow in case of a vertical alignment of the oscillation axis **46** during the movement of the portal **22** and/or of the carrier **26**, when viewed in a vertical projection.

For compensating the change of the vertical distance of the tip **52** of the cutting knife **32** from the material supporting surface **20**, the level or height of the tangential or rotary drive **44** on the carrier **26** is adjustable, so that the drive **44** can be raised or lowered when there is a change of the pivot position of the cutting knife **32**, as shown in FIGS. **3** and **4**. Depending on whether the oscillation drive **36** is pivoted manually or with a motor, this setting is also carried out manually or with a motor respectively. The degree of compensation in the direction of the Z-axis is

$$K(z)=A\times(1-\cos\alpha)$$

where A is the vertical distance of the pivot axis **106** from the material supporting surface **20** and where α is the angle of inclination of the oscillation axis **46** of the cutting knife **32** with respect to its initial vertical position, as shown in FIG. **4**.

In order to compensate for the deviations of the tip **52** of the cutting knife **32** from the programmed movement path in the direction of the X- or Y-axis respectively, during a pivoting movement of the oscillation drive **36** around the pivot axis **106**, the portal drive and/or the carrier drive are activated in order to move the portal **22** and/or the carrier **26** along the X-axis or Y-axis respectively in the opposite direction, where the movement of the portal **22** and/or the carrier **26** corresponds to the deviation. Here the degree of compensation in the direction of the X-axis, that is, the movement required of the portal **22** in the X-direction with respect to the cutting table **14**, is:

$$K(x)=A\times\sin\alpha\times\cos\beta.$$

The degree of compensation in the direction of the Y-axis, that is, the movement of the carrier **26** in the Y-direction with respect to the cutting table **14**, which is necessary for the compensation, is:

$$K(y)=A\times\sin\alpha\times\sin\beta,$$

where A is the vertical distance of the pivot axis **106** from the material supporting surface **20**, where α is the angle of inclination of the oscillation axis **46** of the cutting knife **32** with respect to its initial vertical position, as shown in FIG. **4**, and where β is the angle of rotation of the drive shaft **42** of the tangential or rotary drive **44**, and thus the angle of rotation of the components **32**, **36**, **38** in a plane that is parallel to the material supporting surface **20**, with respect to an initial position (FIG. **2**), in which the motor shaft **56** and the pivot axis **106** are parallel to the portal **22**.

With the device **10** described above, the cutting knife **32** can be driven with an oscillation frequency of 18,000 oscillations per minute and an exact piston or knife stroke of 1.6 mm. In comparison to a pneumatic cutting unit, the cut has an adjustable, constant cutting depth.

The oscillation frequency can be altered, since an rpm-controlled motor is used as the electric motor, while the piston stroke can be altered by replacing the eccentric ring **84** by another eccentric ring **84** with a larger or smaller eccentricity.

Although certain cutting devices and cutting units and features and characteristics thereof have been described herein in accordance with the teachings of the present disclosure, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all embodiments of the teachings of the disclosure that fairly fall within the scope of permissible equivalents.

What is claimed is:

1. A device for the cutting of material on a plane material supporting surface, the device having the plane material supporting surface and at least one cutting unit, wherein the at least one cutting unit can be motor-driven in a controlled manner above and across the material supporting surface in a direction of an X- and Y-axis of a Cartesian coordinate system that is parallel to the material supporting surface, wherein the at least one cutting unit is mounted on a carrier and wherein the carrier is controllably movable in the direction of the X-axis and Y-axis of the Cartesian coordinate system, wherein the at least one cutting unit comprises an oscillation drive and a cutting knife, wherein the oscillation drive sets the cutting knife into linear oscillations having an oscillation axis that is perpendicular to an advancing direction of the cutting knife, wherein for changing an angle of inclination of the oscillation axis with respect to the material supporting surface the oscillation drive with the cutting knife is pivotable around a pivot axis that is parallel to the material supporting surface, wherein the oscillation drive comprises an electric motor having a rotary drive shaft that is parallel to the material supporting surface, wherein the rotary axis of the rotary drive shaft is aligned with the pivot axis, wherein the cutting unit comprises a linearly guided knife holder and further comprises a cam between the rotary drive shaft of the oscillation drive and the knife holder, wherein the cam converts the rotation of the rotary drive shaft into an oscillating movement of the knife holder along the oscillation axis, wherein the cam comprises an eccentric ring, wherein the eccentric ring is fixedly connected to the rotary drive shaft, and wherein the eccentric ring has an inner cylindrical surface that is concentric to the rotary axis of the rotary drive shaft and has an outer surface cylindrical surface that is eccentric to the rotary axis of the rotary drive shaft.

2. The device according to claim **1**, wherein the pivot axis and the rotary axis of the rotary drive shaft are perpendicular to the oscillation axis of the cutting knife and intersect the oscillation axis.

3. The device according to claim **1**, wherein the electric motor of the oscillation drive has a motor housing, and wherein the rotary drive shaft projects from the motor housing and is supported in two bearings within the motor housing and in a further bearing outside of the motor housing beyond the oscillation axis.

4. The device according to claim **1**, wherein the carrier is mounted to an arch or portal, wherein the arch or portal is controllably movable in the X-direction with respect to the material supporting surface and wherein the carrier is controllably movable in the Y-direction with respect to the arch or portal.

5. The device according to claim **1**, wherein the at least one cutting unit comprises a holder for the oscillation drive, wherein the holder is attached to the carrier, and wherein the oscillation drive is pivotable around the rotary axis of the rotary drive shaft with respect to the holder.

6. The device according to claim **1**, wherein the at least one cutting unit comprises a controlled tangential or rotary drive for active alignment of the cutting knife and wherein the controlled tangential or rotary drive is arranged between the oscillation drive and the carrier.

7. The device according to claim **6**, wherein the at least one cutting unit comprises a holder for the oscillation drive, wherein the holder is attached to a drive shaft of the tangential or rotary drive, and wherein the oscillation drive is pivotable around the rotary axis of the rotary drive shaft with respect to the holder.

8. The device according to claim **6**, further comprising means for compensating movements of the cutting knife in a direction of the Z-axis of the Cartesian coordinate system, that are caused by pivoting movements of the oscillation drive around the pivot axis, wherein the means for compensating comprise means for adjusting a level or height of the tangential or rotary drive and wherein the compensating movements in the direction of the Z-axis for adjusting the level or height of the tangential or rotary drive are equal to

$$K(z)=A\times(1-\cos\alpha)$$

where A is the distance of the pivot axis from the material supporting surface in the direction of the Z-axis and where α is the angle of inclination of the oscillation axis of the cutting knife with respect to the Z-axis.

9. The device according to claim **6**, further comprising means for compensating movements of the cutting knife in a direction of the X-axis of the Cartesian coordinate system, that are caused by pivoting movements of the oscillation drive around the pivot axis, wherein the means for compensating comprise means for moving the arch or portal along the X-axis in an opposite direction, wherein the compensating movements in the direction of the X-axis are equal to

$$K(x)=A\times\sin\alpha\times\cos\beta$$

where A is the distance of the pivot axis from the material supporting surface in the direction of the Z-axis, where α is the angle of inclination of the oscillation axis of the cutting knife with respect to the Z-axis and where β is the angle of rotation of a drive shaft of the tangential or rotary drive with respect to an initial position.

10. The device according to claim **6**, further comprising means for compensating movements of the cutting knife in a direction of the Y-axis of the Cartesian coordinate system, that are caused by pivoting movements of the oscillation drive around the pivot axis, wherein the means for compensating comprise means for moving the carrier along the Y-axis in an opposite direction, wherein the compensating movements in the direction of the Y-axis are equal to

$$K(y)=A\times\sin\alpha\times\sin\beta$$

where A is the distance of the pivot axis from the material supporting surface in the direction of the Z-axis, where α is the angle of inclination of the oscillation axis of the cutting knife with respect to the Z-axis and where β is the angle of rotation of a drive shaft of the tangential or rotary drive with respect to an initial position.

11. A cutting unit, comprising an oscillation drive, a holder for the oscillation drive, a carrier for the holder and a cutting knife, wherein the oscillation drive sets the cutting knife into linear oscillations having an oscillation axis, which is perpendicular to an advancing direction of the cutting knife, wherein the oscillation drive with the cutting knife is pivotable with respect to the holder around a pivot axis that is perpendicular to the oscillation axis, wherein the oscillation drive comprises an electric motor having a rotary drive shaft and wherein the rotary axis of the rotary drive shaft is aligned with the pivot axis and intersects the oscillation axis, wherein the cutting unit comprises a linearly guided knife holder and further comprises a cam between the rotary drive shaft of the oscillation drive and the knife holder, wherein the cam converts the rotation of the rotary drive shaft into an oscillating movement of the knife holder along the oscillation axis, wherein the cam comprises an eccentric ring, wherein the eccentric ring is fixedly connected to the rotary drive shaft and wherein the eccentric ring has an inner cylindrical surface that is concentric to the rotary axis of the rotary drive shaft and has an outer surface cylindrical surface that is eccentric to the rotary axis of the rotary drive shaft.

12. The cutting unit according to claim **11**, wherein the electric motor of the oscillation drive has a motor housing, and wherein the rotary drive shaft projects from the motor housing and is supported in two bearings within the motor housing and in a further bearing outside of the motor housing beyond the oscillation axis.

13. The cutting unit according to claim **11**, further comprising a controlled tangential or rotary drive for active alignment of the cutting knife.

14. The cutting unit according to claim **13**, further comprising:

a holder for the oscillation drive, wherein the holder is attached to a drive shaft of the tangential or rotary drive, and wherein the oscillation drive is pivotable around the rotary axis of the rotary drive shaft with respect to the holder; and

a clamping ring for clamping the oscillation drive in various angular positions with respect to the holder.

* * * * *