Title of the Invention: A device for perforating panels of material
Abstract Title: Panel perforating device

An apparatus for perforating a panel of material (17, figure 9) such as for a vehicle interior, has a cutting edge 95 driven through the panel into a moveable impacting surface in use. The panel is held in a plane between the cutting edge 95 and impacting surface and may be adjustably positioned by a pantograph (20, figure 1). Preferably, the impacting surface is the surface of a deformable ball 46 mounted in a housing 48 in the cutting table 58, which rotates due to its frictional connection with the panel as it moves within the plane. The cutting edge 95 may be fixed to a distal end of an inner shaft (84, figure 6), concentrically mounted within an outer shaft (90, figure 6) of a driver assembly (68, figure 6), which rotates as it moves axially through the panel. A suction channel (96, figure 9) may extend from the cutting edge 95 through the concentric shafts (84, 90, figure 6) to remove material as it is cut from the panel.
A DEVICE FOR PERFORATING PANELS OF MATERIAL

This invention relates to an apparatus and method of forming perforated and quilted panels. In particular, the invention relates to an apparatus and method of forming perforated and quilted panels for use in the interiors of automotive vehicles.

BACKGROUND

Quilted panels have been used to enhance the luxury appeal of the interiors of automotive vehicles for many years. The design of the quilting can be altered according to the contour stitching used, and the appearance of the panel can be further enhanced by the inclusion of a series of small holes, or perforations, arranged in a stylised fashion between the stitching. The manufacture of such panels is generally a two-stage process. Firstly, an automated sewing or quilting machine is used to apply stitch lines to a panel of material. Secondly, the quilted panel is then moved to a press tool, comprising a male punch and a female die, in order to create an arrangement of holes within and around the stitch lines. There are, however, a number of drawbacks with this two-stage process. For example, misalignment of the panel with respect to the quilting machine and / or the press tool is possible, which can ruin the panel. This is particularly an issue when the panel has already been quilted and is then moved to the press tool. Moreover, any modification to the arrangement of perforations would require new male punch and female die components, which add expense and complexity to the overall process.

The present invention seeks to overcome or substantially mitigate at least the foregoing problems.

STATEMENTS OF INVENTION

According to a first aspect of the invention, there is provided an apparatus for perforating a panel of material comprising a driver assembly, a perforation assembly comprising a cutting edge for cutting the panel of material, an impacting surface and means for holding the panel of material in a material plane between the cutting edge and the impacting surface, wherein the driver assembly is arranged to drive or force the cutting edge through the material plane into the impacting surface to cut the panel of material, the apparatus being characterised in that the impacting surface is moveable with respect to the cutting edge. The fact that the impacting surface is moveable means that the cutting edge is not
repeatedly driven into the same point on the impacting surface during use, which prolongs the use of the impacting surface.

Preferably, the impacting surface is rotatable.

Preferably, the impacting surface is a spherical surface.

Preferably, the impacting surface is the surface of a ball rotatable about a fixed point in space. The ball can be held in a housing and is arranged to sit on a plurality of ball bearings located at the bottom of the housing. Preferably, the interior of the ball is solid and the ball is made substantially of polypropylene with a density between 0.895 and 0.92 g/cm\(^3\) and a Young’s modulus between 1300 and 1800 N/mm\(^2\).

Preferably, the apparatus further comprising a positioning means for moving the panel of material in the material plane with respect to the cutting edge. Wherein the material plane is positioned so that the underside of the panel of material held by the holding means contacts the impacting surface providing a frictional connection therebetween, and wherein the impacting surface is moveable as the panel of material is moved in the material plane by the positioning means. This arrangement reduces the complexity of the apparatus by eliminating the need for a separate means of moving the impacting surface.

Preferably, the positioning means comprises a pantograph.

Preferably, the impacting surface is resiliently deformable. That is to say, the impacting surface has a tendency to recover its original form after having been struck by the cutting edge. The fact that the impacting surface is deformable means that the cutting edge is not substantially damaged when driven into the impacting surface. Moreover, the fact that the impacting surface is resiliently deformable means that can be reused before it eventually needs replacing.

Preferably, the driver assembly is arranged to drive the cutting edge into the impacting surface against a biasing means.

According to a second aspect of the invention, there is provided a method of perforating a panel of material comprising the steps of holding the panel of material in a material plane between a cutting edge and an impacting surface; driving or pushing the cutting edge
through the material plane into the impacting surface to cut the panel of material; and, moving the impacting surface with respect to the cutting edge.

Preferably, the impacting surface is moved by being rotated.

Preferably, the impacting surface is rotated about a fixed point.

Preferably, the method further comprises the steps of positioning the material plane so that the underside of the panel of material contacts the impacting surface to provide a frictional connection therebetween and moving the panel of material in the material plane to move the impacting surface.

According to a third aspect of the invention, there is provided an apparatus for perforating a panel of material comprising a driver assembly, a perforation assembly comprising a cutting edge for cutting the panel of material and means for holding the panel of material in a material plane, wherein the driver assembly is arranged to drive the cutting edge from an uppermost position through the material plane to a lowermost position to cut the panel of material, the apparatus being characterised in that the perforation assembly further comprises means for rotating the cutting edge during movement from the uppermost position to the lowermost position. The fact that the cutting edge is arranged to rotate means that it cuts into the panel of material as opposed to the shearing action seen in conventional press tools comprising a male punch and a female die, which tends to tear or rip the material. This improves the finish of the perforations, which increases the quality of the panel of material and can also increase its useful life.

Preferably, the perforation assembly further comprises a hollow first shaft secured to the driver assembly and a second shaft on which the cutting edge is fixedly mounted, the second shaft being concentrically mounted within the first shaft and configured for axial movement with respect to the first shaft when the cutting edge is driven from the uppermost position to the lowermost position, wherein the rotating means is arranged to rotate the cutting edge during the respective axial movement between the first and second shafts. That is, the cutting edge is required to rotate at some point during its movement from the uppermost position to the lowermost position. The respective axial movement moves the shafts from an expanded configuration to a compressed configuration when the cutting edge is driven from the uppermost position to the lowermost position respectively.
Preferably, the rotating means comprises a roller rotatably secured to the second shaft and an open track coiling around the first shaft, wherein the roller is configured for movement along the open track from a lowermost point to an uppermost point during the respective axial movement between the first and second shafts. This provides a straightforward arrangement of translating the respective axial movement into a rotational movement, in which only the roller needs replacing occasionally. Preferably, the roller is made of a synthetic resin. The fact that the roller is made of a synthetic resin means that it is less likely to damage the first shaft as it moves along the open track.

Preferably, the second shaft is configured to move axially with respect to the first shaft by means of a force applied to the cutting edge from the panel of material during movement of the cutting edge from the uppermost position to the lowermost position.

Preferably, the second shaft is configured to move axially with respect to the first shaft against a biasing means. Moreover, the driver assembly is also arranged to drive the cutting edge from the uppermost position to the lowermost position against a biasing means.

Preferably, the cutting edge is arranged to rotate at least by 30 degrees. More preferably, the cutting edge is arranged to rotate by 40 degrees. This arrangement ensures that the cutting edge rotates all of the way through the panel of material. That is to say, the cutting edge cuts all of the way through the panel of material. The extent to which the cutting edge rotates can be varied according to the thickness of the panel of material.

Preferably, the means for holding the panel of material in the material plane is moveable.

According to a fourth aspect of the invention, there is provided a method for perforating a panel of material comprising the steps of holding a panel of material in a material plane; driving a cutting edge from an uppermost position through the material plane to a lowermost position to cut the panel of material; and, rotating the cutting edge during movement from the uppermost position to the lowermost position.

Preferably, the cutting edge is rotated by at least 30 degrees.

According to a fifth aspect of the invention, there is provided an apparatus for perforating a panel of material comprising a driver assembly, a perforation assembly comprising a cutting edge for cutting a slug of material from the panel of material and means for holding
the panel of material in a material plane, wherein the driver assembly is arranged to drive
the cutting edge from an uppermost position through the material plane to a lowermost
position to cut the slug of material from the panel of material, the apparatus being
characterised in that the perforation assembly further comprises a channel extending from
the cutting edge, the channel being arranged to receive the slug of material as the cutting
e edge is driven through the material plane to cut the slug of material from the panel of
material, and a suction means in fluidic communication with the channel, the suction
means being arranged to create low pressure within the channel for removing the slug of
material from the channel. Low pressure, in this instance, refers to a static pressure that
is lower than the atmospheric pressure.

Preferably, the perforation assembly further comprises means for rotating the cutting edge
during movement from the uppermost position to the lowermost position. Preferably, the
means for holding the panel of material in the material plane is moveable.

Preferably, the perforation assembly further comprises a first shaft secured to the driver
assembly and a second shaft on which the cutting edge is fixedly mounted, the second
shaft being concentrically mounted within the first shaft and configured for axial movement
with respect to the first shaft when the cutting edge is driven from the uppermost position
to the lowermost position, wherein the rotating means is arranged to rotate the cutting
edge during the respective axial movement between the first and second shafts.

Preferably, the rotating means comprises a roller rotatably secured to the second shaft
and an open track coiling around the first shaft, wherein the roller is configured for
movement along the open track from a lowermost point to an uppermost point during the
respective axial movement between the first and second shafts.

Preferably, the second shaft is configured to move axially with respect to the first shaft by
means of a force applied to the cutting edge from the panel of material during movement
of the cutting edge from the uppermost position to the lowermost position.

Preferably, the second shaft is configured to move axially with respect to the first shaft
against a biasing means. Moreover, the driver assembly is also arranged to drive the
cutting edge from the uppermost position to the lowermost position against a biasing
means.
Preferably, the suction means is connected to the channel by a flexible tube, which is connected to the channel by a quick-fix connector.

According to a sixth aspect of the invention, there is provided a method for perforating a panel of material comprising the steps of holding a panel of material in a material plane; driving a cutting edge from an uppermost position through the material plane to a lowermost position to cut a slug of material from the panel of material; receiving the slug of material in a channel connected to the cutting edge as the cutting edge is driven through the material plane to cut the slug of material from the panel of material; and, creating a low pressure, relative to the atmospheric pressure, within the channel for removing the slug of material from the channel.

Preferably, the method further comprising the step of rotating the cutting edge during its movement from the uppermost position to the lowermost position.

According to a seventh aspect of the invention, there is provided a quilting and perforating machine comprising an apparatus according to the first, third or fifth aspects of the present invention.

DRAWINGS

The above and other aspects of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a front perspective view of a quilting and perforating machine in accordance with the present invention;

FIG. 2 is a rear perspective view of the machine of FIG. 1;

FIG. 3 is a perspective view of a perforating device for use with the machine of FIG. 1;

FIG. 4 is a perspective view of the interior of the perforating device of FIG. 3;

FIG. 5 is an exploded view of part of a driver assembly of the perforating device of FIG. 3;

FIG. 6 is an exploded view of a perforation assembly used in the perforating device of FIG. 3;
FIG. 7 is a side view of a perforating head of the perforating device of FIG. 3, together with a sectional view of a sacrificial ball and ball housing;

FIG. 8 is a schematic representation of the various stages of perforating a panel of material using a conventional press tool; and,

FIG. 9 is a schematic representation of the various stages of perforating a panel of material using the perforating device of FIG. 3.

In the drawings, like parts are denoted by like reference numerals.

SPECIFIC DESCRIPTION

FIG. 1 and FIG. 2 show a quilting and perforating machine, generally designated by 2, comprising a quilting device 4 and a perforating device 6 (shown without their respective housings). The quilting device 4 and the perforating device 6 comprise a stitching head 5 and a perforating head 7 respectively, and are fixedly mounted to respective brackets 9. The stitching head 5 is a conventional stitching head comprising a plurality of positions for accommodating different needles, each of which may use a different coloured thread for sewing. The machine 2 further comprises a transverse beam 8, which functions to hold the brackets 9 in a fixed location above a substantially level upper surface 10 of a table 3. The surface 10 comprises two apertures 12, 14, one 12 of which is located directly beneath the stitching head 5 whilst the other 14 is located directly beneath the perforating head 7. Both apertures 12, 14 are partly covered by a needle plate 16 comprising a small opening 18. A moveable pantograph 20 is located above the surface 10 and comprises several components 22 fixed relative to each other in a generally rectangular configuration, together with at least one inner frame 24. The inner frame 24 functions to hold separate panels of material within the pantograph 20 to be quilted and perforated. The surface 10 further comprises five tracks 28, three of which extend laterally for approximately a third of the length of the surface 10, with the remaining two tracks 28 extending across the surface 10 perpendicular to the lateral tracks. Two motors (not shown) control movement of the pantograph 20 along the tracks 28 in a horizontal plane above the surface 10 so as to position a panel of material held in the pantograph 20 with respect to the stitching and perforating heads 5, 7. Control of the quilting device 4, the perforating device 6 and the two motors controlling the pantograph 20 is automated by the use of computer numerical control. This allows any number of designs to be applied to
the panel of material using the same quilting device 4 and perforating device 6. In particular, it avoids the need for different male punch and female die components for different arrangements of perforations.

FIG. 3 shows the perforating device 6 comprising the perforating head 7 and a housing 30, together with a suction tube 32 extending through a hole 36 in the housing 30 to the transverse beam 8. The housing 30 is fixed to the beam 8 using a plurality of bolts 34 so as to provide easy access to the interior of the perforating device 6. The housing 30 can be removed to gain access to the interior of the perforating device 6 firstly by releasing the bolts 34 and disconnecting the suction tube 32 from the beam 8. The housing 30 can then be lifted up, allowing the suction tube 32 to pass through the hole 36, and away from the beam 8.

FIG. 4 shows the interior of the perforating device 6. The suction tube 32 is connected to a perforation or driven assembly, generally designated by 64, by a quick-fix connector or the like, and extends through the beam 8 to a collection bucket 66, as shown in FIG. 1. The perforating device 6 further comprises a base 25, through which part of the perforation assembly 64 extends, and a driver assembly, generally designated by 68, arranged to drive or push the perforation assembly 64 downwards against the biasing force of a compression coil spring 70. The driver assembly 68 comprises a transducer, such as an electromechanical solenoid, for converting electrical energy into linear motion for driving the perforation assembly 64 up to 460 times per minute. The driver assembly 68 further comprises a vertical drive shaft 72, for guiding the linear motion of the driver assembly 68. A bracket 74 forms part of the driver assembly 68 and is arranged for movement along the drive shaft 72 in upwards and downwards directions. With reference to FIG. 5, a driver fixing base 76 is fixedly connected to the upper section of the bracket 74 by at least one socket bolt. Two arms 77 protrude from the lower section of the driver fixing base 76, one arm being positioned directly above the other arm to define a space therebetween. A driver component 78 is held under the lower arm by a driver pin 27 extending through the component 78 and the arms 77. A torsion coil spring 79 is positioned around the driver pin in the space defined between the arms 77. One end of the torsion coil spring 79 is fixed to the side of the driver fixing base 76 and the other end is arranged to be held in a cavity defined by a cylindrical section 80 upwardly extending from the upper surface of the driver component 78. The torsion coil spring 79 functions to hold the driver component 78 in position thereby preventing relative rotation of the driver component 78 about the driver pin 27 with respect to the other components of the driver assembly 68. The driver component 78 is held between two driver guides 82 of the
perforation assembly 64 to provide a connection therebetween and transfer the linear motion of the driver assembly 68 to the perforation assembly 64.

Turning to FIG. 6, the perforation assembly 64 comprises a hollow cylindrical rotation shaft 84 including a central section 85, and upper and lower end sections generally designated by 86. The central section 85 has a larger diameter when compared to the end sections 86 and includes a screw hole 88. A compression coil spring 89 is positioned around the upper end section 86 and rests on a shoulder 87 created at the junction between the central section 85 and the upper end section 86. The perforation assembly 64 further comprises a sliding shaft 90 that is arranged to slide over the rotation shaft 84 in a concentric arrangement. Preferably, the sliding shaft 90 is made of aluminium in order to reduce the overall weight of the perforation assembly 64 and, in turn, increase the maximum velocity at which the perforation assembly 64 can be moved by the driver assembly 68. A fixing nut 91 is used to hold the sliding shaft 90 about the rotation shaft 84 to establish a small clearance between the outer surface of the central section 85 and the inner surface of the sliding shaft 90, thereby allowing rotation of the rotation shaft 84 relative to the sliding shaft 90 about its longitudinal axis. When the perforation assembly 64 is assembled, the spring 89 is held between a shoulder 87 of the rotation shaft 84, defined between the central section 85 and the upper end section 86, and an opposing surface inside the sliding shaft 90. The sliding shaft 90 comprises an open track 93 defining a path that coils around substantially a third of the shaft’s circumference, the lowermost section of which is arranged to line up with the screw hole 88 in the central section 85 of the rotation shaft 84. The screw hole 88 is arranged to receive a shoulder button bolt, or the like, which configured to carry a roller 94. The rotation shaft 84 is configured to move upwards with respect to the sliding shaft 90 against the biasing force of the spring 89 during the operation of the perforation assembly 64. This relative axial movement causes the roller 94 to move along the open track 93 thereby causing a simultaneous rotation of the rotation shaft 84 within the sliding shaft 90. Preferably, the roller 94 is made of a synthetic resin, which is a softer material than metal, ensuring that the roller 94 is less likely to damage the rotation shaft 84 as it moves along the open track 93. This is particularly important when the sliding shaft 90 is itself made of a relatively soft material such as aluminium. The extent to which the rotation shaft 84 can rotate within the sliding shaft 90 is limited by the length of the open track 93. In the embodiment shown, the respective rotation between the shafts 84, 90 is approximately 40 degrees. However, it will be apparent to those skilled in the art that the perforation assembly 64 could be configured such that the respective rotation between the shafts 84, 90 is more or less than 40 degrees.
FIG. 7 shows the perforating unit 64 comprising a concentrically mounted hollow perforation knife 38. The knife 38 is removably connected to the lower end of the rotation shaft 84 by a fixing nut 42. The knife 38 comprises a frusto-conical surface tip portion that terminates in a circular cutting edge 95, together with a cylindrical channel 96 extending through the knife 38 from the cutting edge 95 to the end of the knife 38 remote from the cutting edge 95. The cylindrical channel 96 is in fluidic communication with the hollow interior of the rotation shaft 84 when the knife 38 is connected thereto. The knife 38 is inserted into a hole in the bottom of the fixing nut 42 and is secured in position by a frictional connection created by a screw 44 located in the side of the fixing nut 42. This convenient arrangement of securing the knife 38 to the fixing nut 42 avoids the need to remove the housing 30 when replacing the knife 38. A resiliently deformable sacrificial ball 46 protrudes through the opening 18 in the needle plate 16 located directly below the knife 38 and functions as a rotatable spherical surface into which the cutting edge 95 impacts during the operation of the perforation assembly 64. In the embodiment shown, the diameter of the ball 46 is 40mm. Preferably, the ball 46 is solid and is made of substantially polypropylene with a density between 0.855 and 0.946 g/cm³ and a Young’s modulus between 1300 and 1800 N/mm². This ensures that the ball 46 remains useable for substantially 30,000 impacts of the cutting edge before it needs replacing. When a panel of material is held in the inner frame 24, the part of the ball 46 extending above the upper surface of the needle plate 16 directly contacts the underside of the panel of material to establish a frictional connection therebetween. In the embodiment shown, the upper section of the ball 46 extends approximately 2mm above the upper surface of the needle plate 16. The ball 46 is held in a cylindrical ball housing 48. The base of the housing 48 comprises a concentric bearing race 50 for guiding a plurality of ball bearings 52 spaced at equal circumferential intervals. The ball bearings 52 are free to rotate on the bearing race 50. Alternatively, the ball bearings 52 may be placed directly on the base of the housing 48. Twelve ball bearings 52 are used in the embodiment shown. The ball 46 is arranged to sit on the plurality of ball bearings 52 thereby establishing direct connection between the ball 46 and each ball bearing 52. The ball bearings 52 function firstly to concentrically align the ball 46 with the main axis of the housing 48 thereby preventing the ball 46 from touching the internal sides of the housing 48. Secondly, the arrangement of the ball bearings 52 allows the ball 46 to rotate within the housing 48 in all directions whilst maintaining its alignment with the main axis of the housing 48. That is, the ball 46 is configured to remain in a fixed point in space while it rotates about that point in any direction. The upper end of the housing 48 includes a flange 54, the bottom surface of which is arranged to meet the upper surface of a flanged section of a perforation bed 58 to
hold the housing 48 from the perforation bed 58. The housing 48 is secured to the perforation bed 58 by a plurality of socket bolts. The housing 48 further comprises a concentric access hole 62, which is located directly below the ball 46. A screw driver or the like can be inserted through the access hole 62 to lift the ball 46 from the housing 48, thereby allowing replacement of the ball 46 without first having to remove the housing 48 from the perforation bed 58.

FIG. 8 is a schematic representation of the various stages of perforating a panel of laminated material 17 using a conventional press tool comprising a male punch 19 and a female die 21. In this instance, the panel of material 17 will already have been quilted. The panel of material 17 is held between the male punch 19 and the female die 21, and the male punch 19 is moved downwards towards the female die 21 along a substantially linear path. The shearing force created in the panel of material 17 by the movement of the male punch 19 relative to the female die 21 causes a slug 23 of material to be torn from the panel of material 17 and the continued movement of the male punch 19 pushes the slug 23 through the female die 21. A suction may be applied downstream of the female die 21 to assist with the removal of the slug 23 to a collection bucket held underneath the press tool. As multiple slugs 23 are being punched at once, the collection bucket tends to be an open vessel. This can result in dust or the like escaping from the collection bucket. The male punch 19 is then moved upwards leaving a hole in the panel of material 17.

FIG. 9 is a schematic representation of the steps of perforating a panel of material 17 using the perforating device 6 of the present invention. Six general steps are shown. In step 1, starting from an initial position or uppermost position, the perforation assembly 64 is moved downwards along its longitudinal axis by the driver assembly 68 towards the panel of material 17 held by the inner frame 24 between the cutting edge 95 of the knife 38 and the sacrificial ball 46.

An upwards force is applied to the cutting edge 95 as the cutting edge 95 contacts the panel of material 17, as shown in step 2. This upwards force impedes the downwards movement, or feed motion, of the rotation shaft 84 when compared to the downwards movement of the sliding shaft 90 causing relatively movement therebetween, which acts against the biasing force of the spring 70. That is, the upwards force acting on the cutting edge 95 causes the rotation shaft 84 to move upwards relative to the sliding shaft 90. This relative movement in turn causes the roller 94 to move upwards along the upper surface of the open track 93 resulting in a simultaneous rotation of the rotation shaft 84.
within the sliding shaft 90 as the perforating unit 64 continues to move downwards. The combined feed motion and rotational movement produces a cutting force at the cutting edge 95 that cuts into the panel of material 17 as opposed to the shearing action used by a conventional press tool. In the embodiment shown the rotation shaft 84 rotates in a clockwise direction during the feed motion. However, it will be apparent to those skilled in the art that the perforation assembly 64 could be configured such that the rotation shaft 84 rotates in an anticlockwise direction during the feed motion.

The simultaneous downward and rotational movement of the knife 38, caused by the relative linear movement between the rotation shaft 84 and the sliding shaft 90 against the biasing force of the spring 70, continues until the downward movement of the driver assembly 68 is completed, which marks the end of the feed motion and defines the lowermost position of the cutting edge 95. The end of the feed motion is arranged substantially to coincide with the point at which the cutting edge 95 impacts the resiliently deformable ball 46 as shown in step 3. The rotation of the rotation shaft 84 during the feed motion is also complete at this point since the roller 94 as reached the end of the open track 93 preventing any further upward movement of the rotation shaft 84 relative to the sliding shaft 90. At the end of the feed motion a slug 23 has been cut out of the panel of material 17 and is held in the interior of the knife 38.

Step 4 shows the start of the upward movement, or return motion, of the perforation assembly 64. At this stage, the spring 70, arranged to resist downward movement of the driver assembly 68, is compressed. Similarly, the spring 89 held between the shoulder 87 of the rotation shaft 84 and an opposing surface inside the sliding shaft 90 is also compressed. The force produced from the impact of the cutting edge 95 on the ball 46 is transferred from the rotation shaft 84 to the sliding shaft 90 by the spring 89 causing the sliding shaft 90 to move upwards together with the driver assembly 68. The upwards movement of the sliding shaft 90 and the driver assembly 68 is assisted by the spring 70, which urges the driver assembly 68 away from the base 25 of the perforation device 6.

The force produced by the spring 89 of the perforation assembly 64, which functions to urge the rotation and sliding shafts 84, 90 apart, is sufficient to overcome frictional forces between the shafts 84, 90 so that the upwards movement of the sliding shaft 90 is not transferred to the rotation shaft 84 during the initial stage of the return motion. That is, the rotation shaft 84 is prevented from moving upwards during the initial stage of the return motion by the spring 89 whereas the sliding shaft 90 is configured to move upwards, relative to the rotation shaft 84. Upward movement of the sliding shaft 90 relative to the rotation shaft 84 causes the roller 94 to move downwards along the lower surface of the
open track 93. This movement, in turn, causes the rotation shaft 84 to rotate in an anticlockwise direction.

The rotation of the rotation shaft 84 during the return motion is completed once to roller 94 reaches the lower end of the open track 93. Continued upward movement of the sliding shaft 90 from this point lifts the knife 38 out of the bore created in the panel of material 17 and the shafts 84, 90 move together back to the initial position preceding step 1, as shown in step 5.

Turning to step 6, once the perforation assembly 64 has returned to the initial position, the panel of material 17 can be moved by the pantograph 20 in the horizontal plane relative to the perforation assembly 64 so that a second slug 23 may be cut from the panel of material 17. The frictional engagement between the panel of material 17 and the ball 46 causes the ball 46 to rotate on the ball bearings 52 as the panel of material 46 is moved in the horizontal plane. This movement changes the point at which the cutting edge 95 impacts the ball 46 during the feed motion, as indicated by the “x” in step 6 changing position when compared to the previous steps.

A low pressure or vacuum is applied to the channel in the knife 38 by a motor or the like positioned downstream of the collection bucket 66 throughout these steps. This causes any slugs 23 in the interior of the knife 38 to be sucked up through the channel in the knife 38, the rotation shaft 84 and the suction tube 32, and into the collection bucket 66. This enables the collection of slugs 23 in a closed environment, which prevents dust and the like from being released. The fact that the cutting edge 95 cuts into the panel of material means that the longitudinal sides of the slugs 23 are less frayed when compared to slugs 23 produced by the shearing action of conventional press tools, which tends to tear or rip the material. This makes it easier to suck the slugs 23 into the collection bucket 66.

The above specific embodiment has been described by way of example only, and should therefore be considered as illustrative and not restrictive. It will be appreciated that variations of the described embodiment may be made without departing from the protective scope of the invention as defined by the claims.
CLAIMS

1. An apparatus for perforating a panel of material comprising:
a driver assembly;
a perforation assembly comprising a cutting edge for cutting the panel of material;
an impacting surface; and,
means for holding the panel of material in a material plane between the cutting
dge and the impacting surface, wherein the driver assembly is arranged to drive
the cutting edge through the material plane into the impacting surface to cut the
panel of material, the apparatus being characterised in that the impacting surface
is moveable with respect to the cutting edge.

2. An apparatus according to claim 1, wherein the impacting surface is rotatable.

3. An apparatus according to claims 1 or 2, wherein the impacting surface is a
spherical surface.

4. An apparatus according to claim 3, wherein the impacting surface is the surface of
a ball rotatable about a fixed point.

5. An apparatus according to claim 4, wherein the ball is held in a housing and is
arranged to sit on a plurality of ball bearings located at the bottom of the housing.

6. An apparatus according to any preceding claim further comprising a positioning
means for moving the panel of material in the material plane with respect to the
cutting edge.

7. An apparatus according to claim 6, wherein the material plane is positioned so that
the underside of the panel of material held by the holding means contacts the
impacting surface providing a frictional connection therebetween, and wherein the
impacting surface is moveable as the panel of material is moved in the material
plane by the positioning means.

8. An apparatus according to any preceding claim, wherein the impacting surface is
resiliently deformable.
9. An apparatus according to any preceding claim, wherein the driver assembly is arranged to drive the cutting edge into the impacting surface against a biasing means.

10. A method for perforating a panel of material comprising the steps of:
holding the panel of material in a material plane between a cutting edge and an impacting surface;
driving the cutting edge through the material plane into the impacting surface to cut the panel of material; and,
moving the impacting surface with respect to the cutting edge.

11. A method according to claim 10, wherein the impacting surface is rotated.

12. A method according to claim 11, wherein the impacting surface is rotated about a fixed point.

13. A method according to claims 10 to 12, further comprising the steps of positioning the material plane so that the underside of the panel of material contacts the impacting surface to provide a frictional connection therebetween and moving the panel of material in the material plane to move the impacting surface.

14. An apparatus for perforating a panel of material comprising:
a driver assembly;
a perforation assembly comprising a cutting edge for cutting the panel of material;
and,
means for holding the panel of material in a material plane, wherein the driver assembly is arranged to drive the cutting edge from an uppermost position through the material plane to a lowermost position to cut the panel of material, the apparatus being characterised in that the perforation assembly further comprises means for rotating the cutting edge during movement from the uppermost position to the lowermost position.

15. An apparatus according to claim 14, wherein the perforation assembly further comprises a first shaft secured to the driver assembly and a second shaft on which the cutting edge is fixedly mounted, the second shaft being concentrically mounted within the first shaft and configured for axial movement with respect to the first shaft when the cutting edge is driven from the uppermost position to the lowermost
position, wherein the rotating means is arranged to rotate the cutting edge during the respective axial movement between the first and second shafts.

16. An apparatus according to claim 15, wherein the rotating means comprises a roller rotatably secured to the second shaft and an open track coiling around the first shaft, wherein the roller is configured for movement along the open track from a lowermost point to an uppermost point during the respective axial movement between the first and second shafts.

17. An apparatus according to claims 15 or 16, wherein the second shaft is configured to move axially with respect to the first shaft by means of a force applied to the cutting edge from the panel of material during movement of the cutting edge from the uppermost position to the lowermost position.

18. An apparatus according to claims 15 to 17, wherein the second shaft is configured to move axially with respect to the first shaft against a biasing means.

19. An apparatus according to claims 14 to 18, wherein the cutting edge arranged to rotate by 40 degrees.

20. A method for perforating a panel of material comprising the steps of:
   holding a panel of material in a material plane;
   driving a cutting edge from an uppermost position through the material plane to a lowermost position to cut the panel of material; and,
   rotating the cutting edge during movement from the uppermost position to the lowermost position.

21. A method according to claim 20, wherein the cutting edge is rotated by 40 degrees.

22. An apparatus for perforating a panel of material comprising:
   a driver assembly;
   a perforation assembly comprising a cutting edge for cutting a slug of material from the panel of material; and,
   means for holding the panel of material in a material plane, wherein the driver assembly is arranged to drive the cutting edge from an uppermost position through the material plane to a lowermost position to cut the slug of material from the panel
of material, the apparatus being characterised in that the perforation assembly further comprises a channel extending from the cutting edge, the channel being arranged to receive the slug of material as the cutting edge is driven through the material plane to cut the slug of material from the panel of material, and a suction means in fluidic communication with the channel, the suction means being arranged to create low pressure within the channel for removing the slug of material from the channel.

23. An apparatus according to claim 22, wherein the perforation assembly further comprises means for rotating the cutting edge during movement from the uppermost position to the lowermost position.

24. An apparatus according to claim 23, wherein the perforation assembly further comprises a first shaft secured to the driver assembly and a second shaft on which the cutting edge is fixedly mounted, the second shaft being concentrically mounted within the first shaft and configured for axial movement with respect to the first shaft when the cutting edge is driven from the uppermost position to the lowermost position, wherein the rotating means is arranged to rotate the cutting edge during the respective axial movement between the first and second shafts.

25. An apparatus according to claim 24, wherein the rotating means comprises a roller rotatably secured to the second shaft and an open track coiling around the first shaft, wherein the roller is configured for movement along the open track from a lowermost point to an uppermost point during the respective axial movement between the first and second shafts.

26. An apparatus according to claims 24 or 25, wherein the second shaft is configured to move axially with respect to the first shaft by means of a force applied to the cutting edge from the panel of material during movement of the cutting edge from the uppermost position to the lowermost position.

27. An apparatus according to any one of claims 22 to 26, wherein the suction means is connected to the channel by a flexible tube.

28. An apparatus according to claim 27, wherein the flexible tube is connected to the channel by a quick-fix connector.
29. A method for perforating a panel of material comprising the steps of:
holding a panel of material in a material plane;
driving a cutting edge from an uppermost position through the material plane to a lowermost position to cut a slug of material from the panel of material;
receiving the slug of material in a channel connected to the cutting edge as the cutting edge is driven through the material plane to cut the slug of material from the panel of material; and,
creating a low pressure within the channel for removing the slug of material from the channel.

30. A method according to claim 29, further comprising the step of rotating the cutting edge during movement from the uppermost position to the lowermost position.

31. A quilting and perforating machine comprising an apparatus according to any one of claims 1 to 9, 14 to 19 or 22 to 28.
Application No: GB1610107.3
Claims searched: 1-13, 31
Examiner: Mr David Kirwin
Date of search: 30 November 2016

Patents Act 1977: Search Report under Section 17

<table>
<thead>
<tr>
<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1, 2, 6-13, 31</td>
<td>WO 03/095163 A1 (GEN. BINDING) see figures and paragraphs 12-15, noting cutting edges 14 and rotary impacting surface 24.</td>
</tr>
<tr>
<td>X</td>
<td>1, 2, 6-13, 31</td>
<td>EP 0502237 A1 (SUDO et al.) see abstract and figures, noting cutting edges 7 and rotary impacting surface 16.</td>
</tr>
<tr>
<td>X</td>
<td>1, 2, 6, 7, 9-13, 31</td>
<td>EP 0900637 A2 (MITSUBISHI) see figures 1 &amp; 2, noting cutting edge 2 and rotary impacting surface 7&quot;.</td>
</tr>
<tr>
<td>X</td>
<td>1, 9, 10, 31</td>
<td>GB 955388 A (SOAG) see figures and abstract, noting horizontally movable table 2 for supporting workpiece, and drilling head 3 with spring 17.</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>CN 204172102 U (CHENGDU) see whole document, noting panel of material 103 supported on rotating balls 203.</td>
</tr>
</tbody>
</table>

Categories:

<table>
<thead>
<tr>
<th>X</th>
<th>Document indicating lack of novelty or inventive step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Document indicating lack of inventive step if combined with one or more other documents of same category.</td>
</tr>
<tr>
<td>&amp;</td>
<td>Member of the same patent family</td>
</tr>
</tbody>
</table>

Field of Search:

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

Worldwide search of patent documents classified in the following areas of the IPC:
B26D; B26F

The following online and other databases have been used in the preparation of this search report:
EPODOC, WPI, TXTA
<table>
<thead>
<tr>
<th>Subclass</th>
<th>Subgroup</th>
<th>Valid From</th>
</tr>
</thead>
<tbody>
<tr>
<td>B26D</td>
<td>0007/20</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26D</td>
<td>0007/01</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26D</td>
<td>0007/18</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26F</td>
<td>0001/14</td>
<td>01/01/2006</td>
</tr>
</tbody>
</table>
Patents Act 1977
Further Search Report under Section 17

Documents considered to be relevant:

<table>
<thead>
<tr>
<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>14, 19-23, 27, 29-31</td>
<td>US 6223637 B1 (HANSEN) see whole document.</td>
</tr>
<tr>
<td>X,Y</td>
<td>X: 14-17, 19-21, 31; Y: 23-26, 30</td>
<td>DE 4417110 A1 (DOERFLEIN) see WPI abstract accession no. 1996-000192 and figure.</td>
</tr>
<tr>
<td>X,Y</td>
<td>X: 14-18, 20, 31; Y: 23-26, 30</td>
<td>WO 2006/108111 A2 (BIO-RAD LAB) see figures and paragraphs 14 and 15 in particular.</td>
</tr>
<tr>
<td>X,Y</td>
<td>X: 14-18, 20, 31; Y: 23-26, 30</td>
<td>DE 3037255 A1 (KALWAR) see figures and WPI abstract accession no. 1982-F0749E.</td>
</tr>
<tr>
<td>X,Y</td>
<td>X: 22, 27-29, 31; Y: 23-26, 30</td>
<td>US 4471677 A1 (LISSOT et al.) see figures and column 2, line 41 to column 3, line 2.</td>
</tr>
<tr>
<td>X,Y</td>
<td>X: 22, 29, 31; Y: 23-26, 30</td>
<td>DE 3325906 A1 (HENSEN) see figures and WPI abstract accession no. 1985-032507.</td>
</tr>
</tbody>
</table>

Categories:
- X Document indicating lack of novelty or inventive step
- Y Document indicating lack of inventive step if combined with one or more other documents of
- A Document indicating technological background and/or state of the art.
- P Document published on or after the declared priority date but before the filing date of this invention.
Field of Search:
Search of GB, EP, WO & US patent documents classified in the following areas of the UKC:

Worldwide search of patent documents classified in the following areas of the IPC
B26D; B26F

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

International Classification:

<table>
<thead>
<tr>
<th>Subclass</th>
<th>Subgroup</th>
<th>Valid From</th>
</tr>
</thead>
<tbody>
<tr>
<td>B26D</td>
<td>0007/20</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26D</td>
<td>0005/00</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26D</td>
<td>0007/01</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26D</td>
<td>0007/18</td>
<td>01/01/2006</td>
</tr>
<tr>
<td>B26F</td>
<td>0001/14</td>
<td>01/01/2006</td>
</tr>
</tbody>
</table>