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Other: **WPI, EPODOC**

(54) Title of the Invention: **Tape deposition head**
Abstract Title: **Tape deposition head**

(57) A tape deposition head for applying lengths of tape 4 to a deposition surface 15 comprises: a tape cutter 13 comprising a feed roller configured to drive the tape through the tape cutter from a tape inlet to a tape outlet along a tape path; a nip roller acting against the feed roller to press the tape against the feed roller; and a tape slicer having a blade for cutting the tape into lengths, the tape slicer being positioned between the feed roller and the tape outlet along the tape path; and a tape conveyor positioned at the tape outlet, the tape conveyor comprising: a belt 16 that runs between a capture roller 17 and a deposition roller 18, the capture roller being positioned proximal to the tape outlet so that tape exiting the tape outlet contacts the belt, the belt being configured to move a cut length of tape to the deposition roller for deposition of the length of tape on to the deposition surface. The tape conveyor may comprise a vacuum chamber 30 to hold the length of tape to the belt. A glue spray 31 may be provided and an air outlet 36 positioned within the deposition roller to produce a jet that forces the length of tape from the belt towards the surface.

FIGURE 1

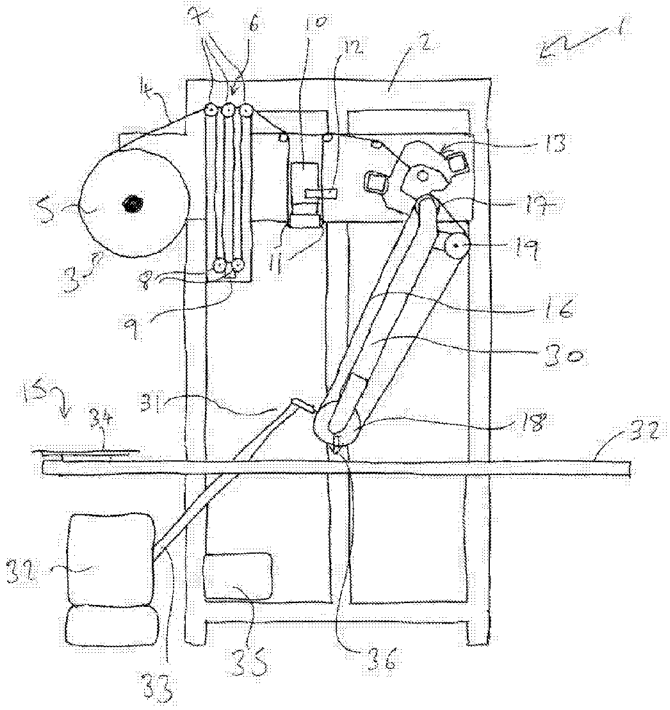

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FIGURE 1

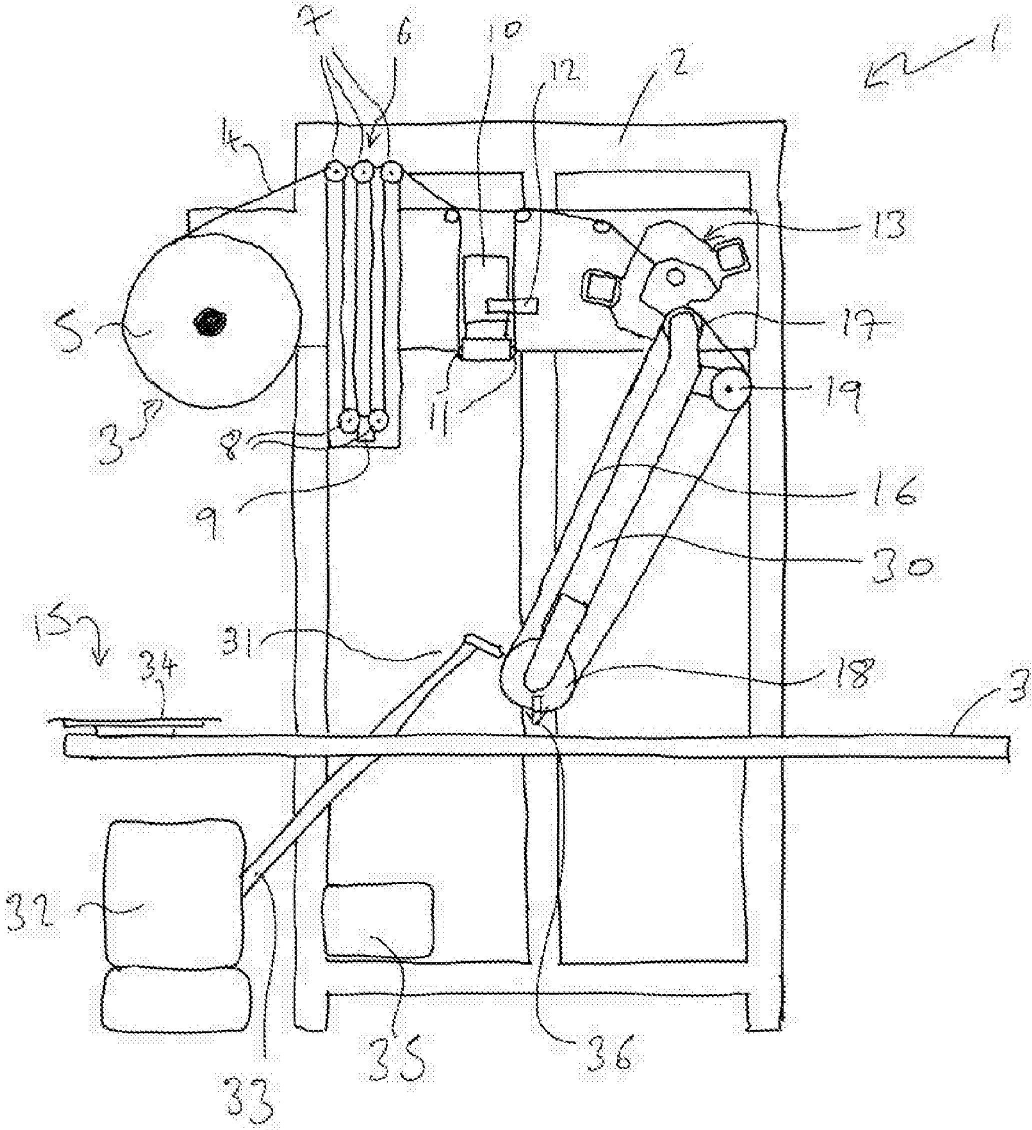


FIGURE 2.

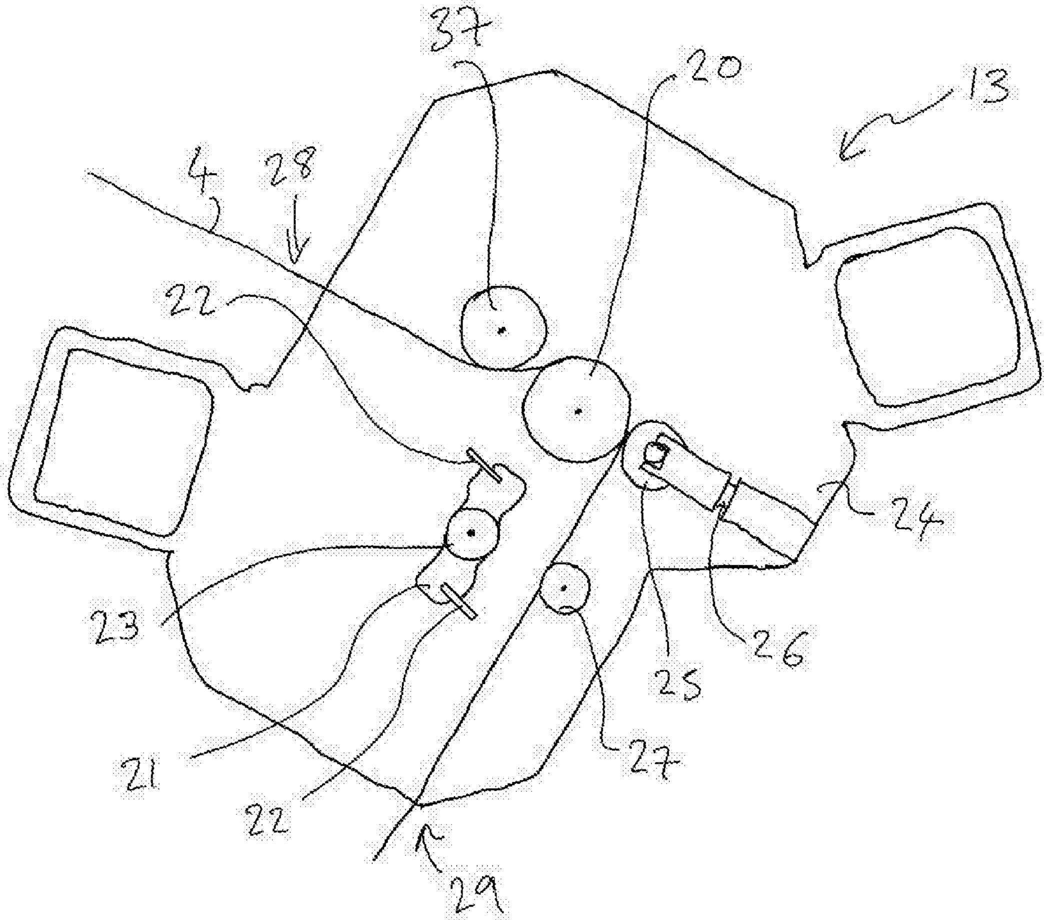


FIGURE 3.

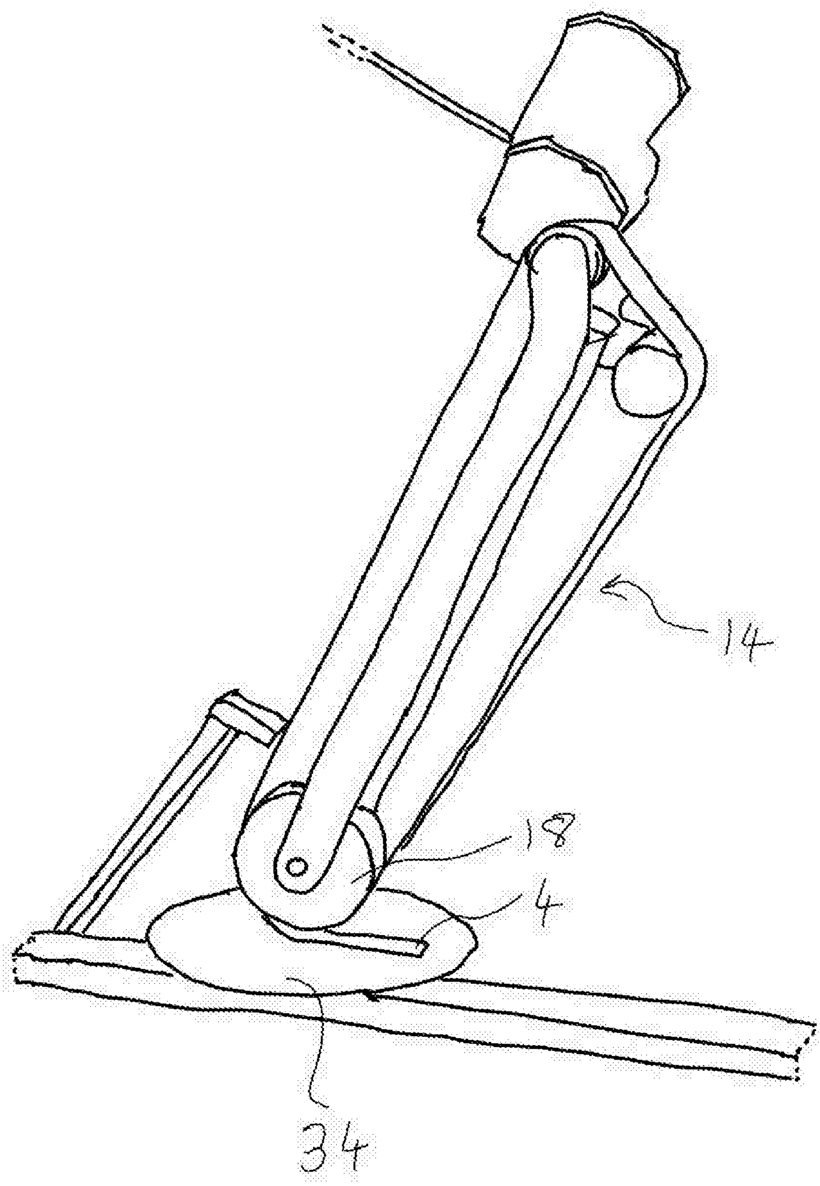
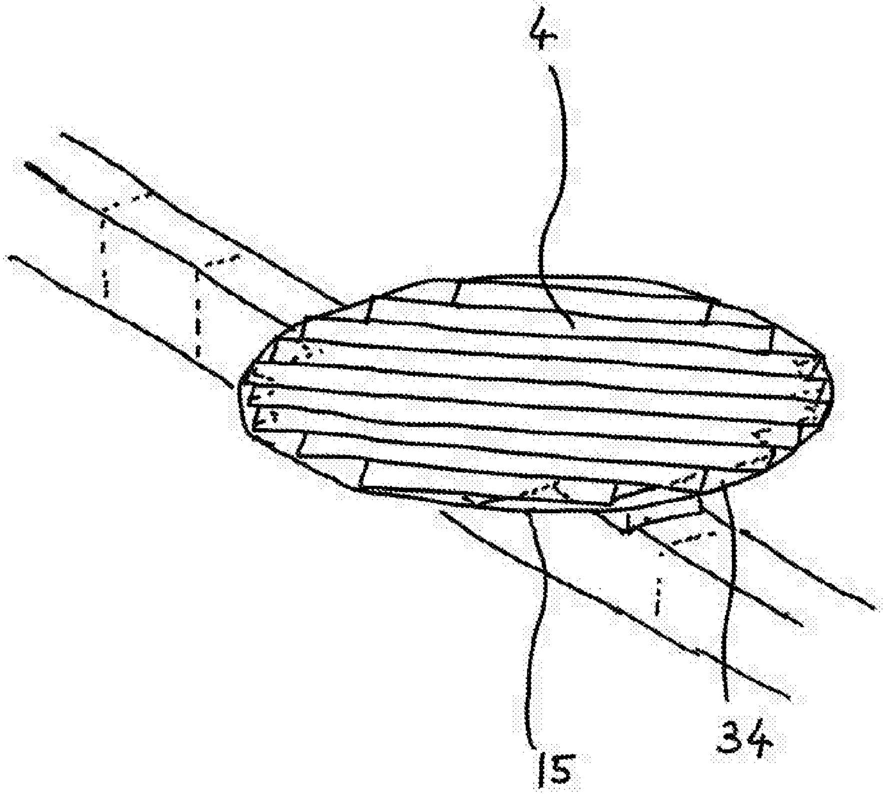


FIGURE 4



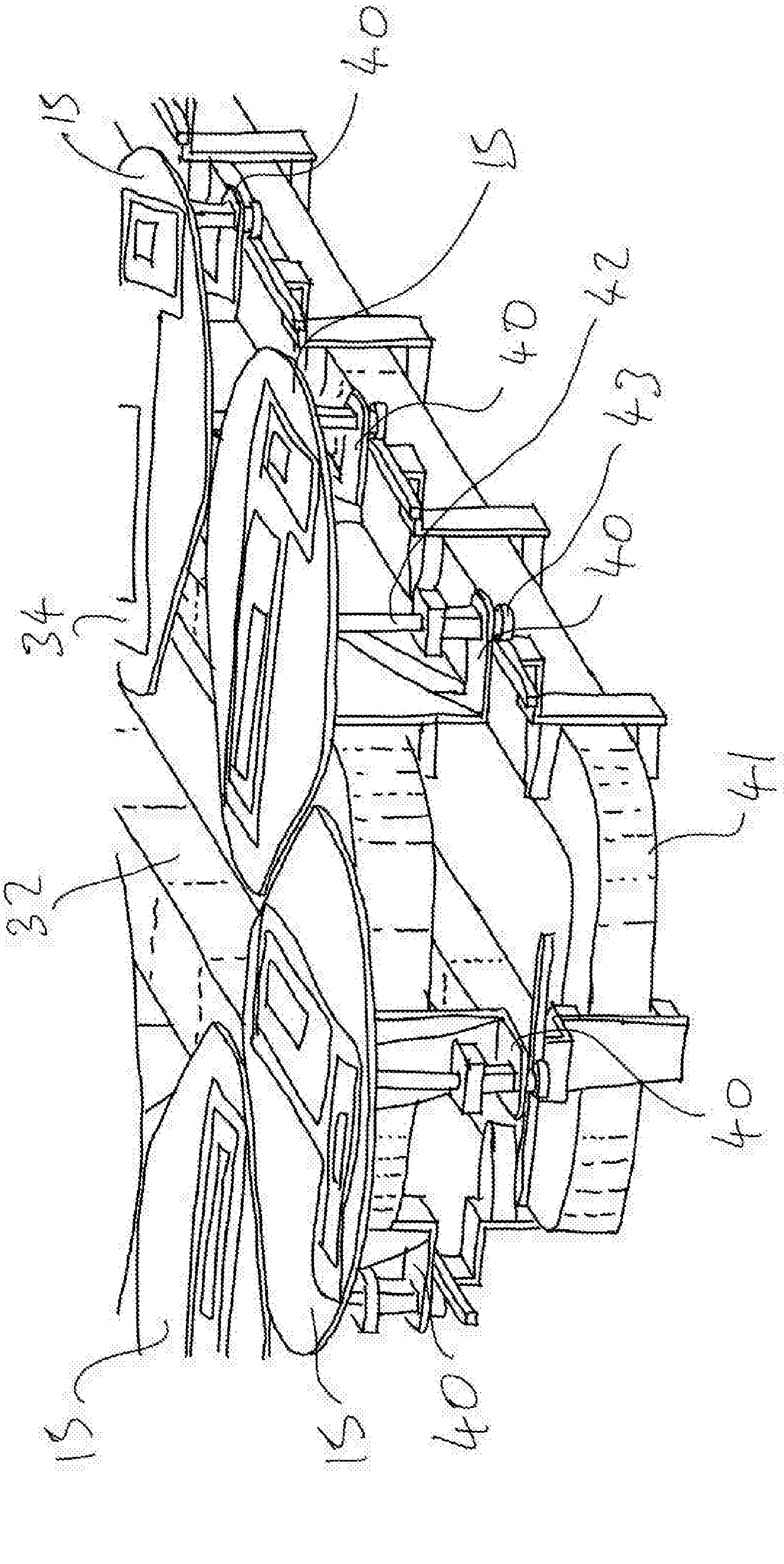


FIGURE 5

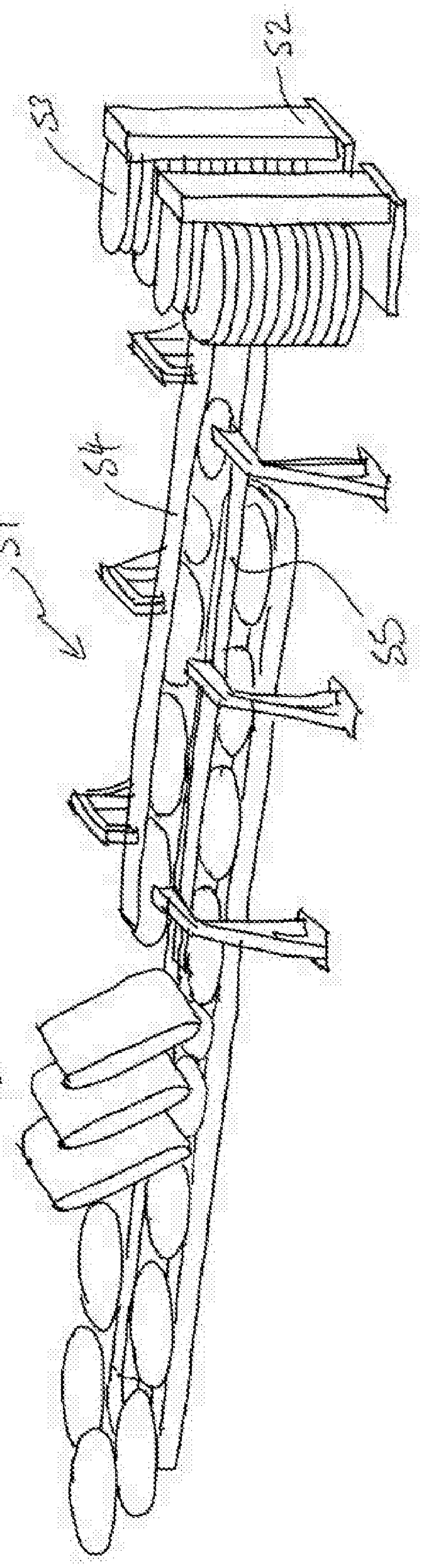


FIGURE 6

FIGURE 7.

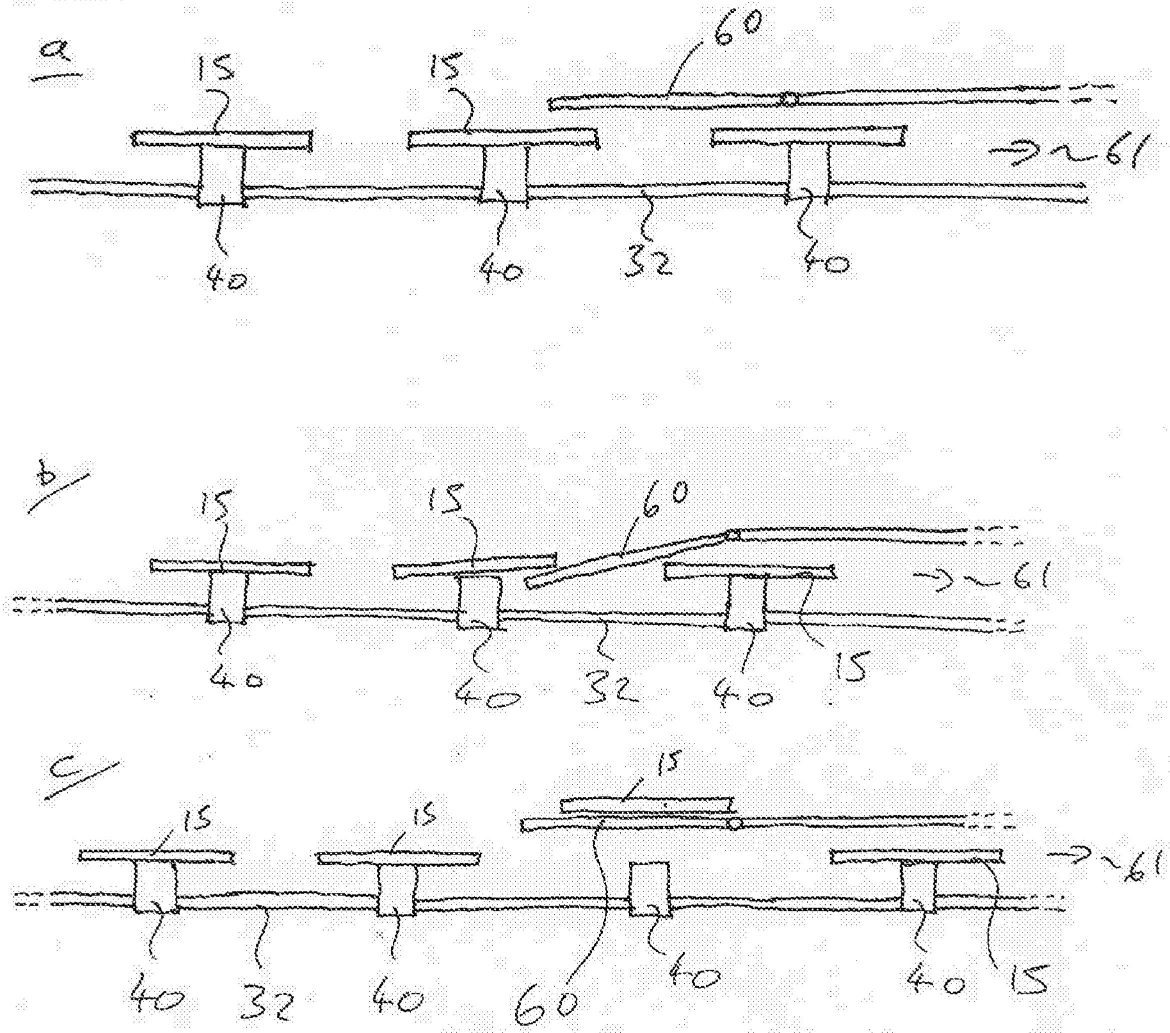

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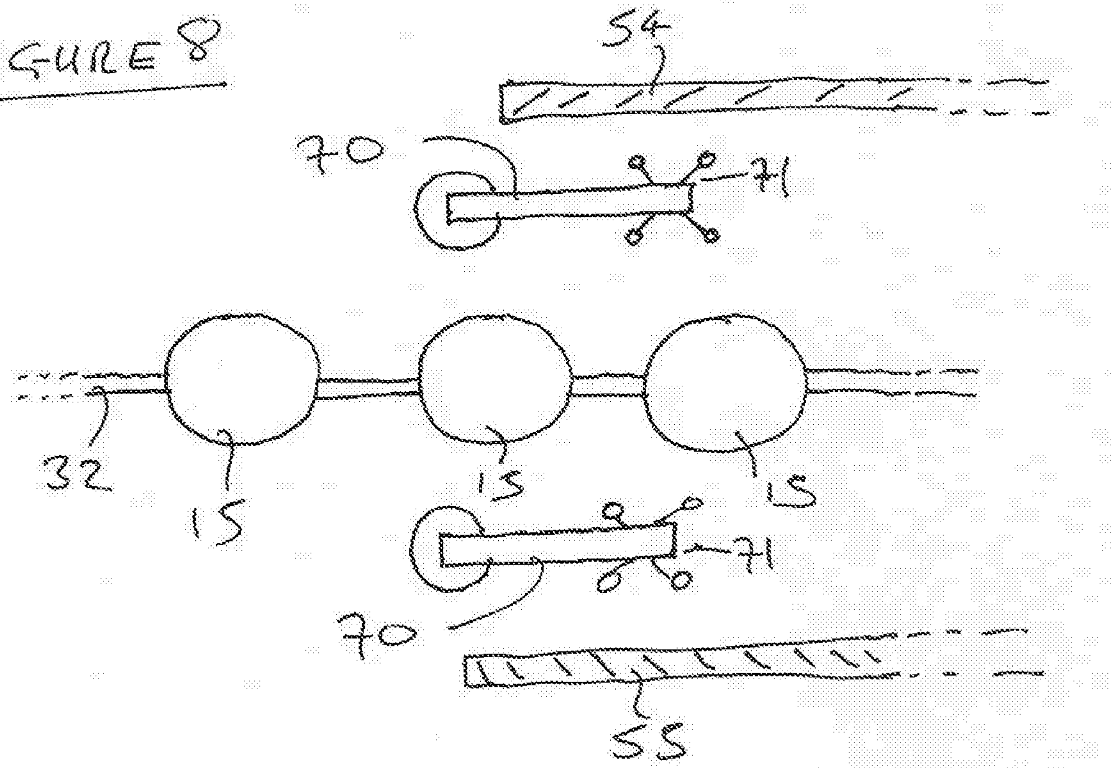
FIGURE 8



TAPE DEPOSITION HEAD

This invention relates to a tape deposition head.

Carbon fibre preforms, boat sails and garments are examples of articles that are made by joining together multiple pliable sheets of material. When such articles are being manufactured it is necessary to bring those sheets together in a desired relationship before the sheets are adhered together. The sheets may then be transferred to a machines that can fix them together permanently. These processes can be difficult because the size of the sheets, and their pliable nature, can make them difficult to handle. For illustration, a typical carbon fibre preform is made up of multiple sheets of carbon fibre material of particular shapes and sizes. These need to be brought together, or laid up, so that they overlap in desired locations and with the weave of each sheet in a desired orientation. Arranging the sheets in this way gives the eventual structure certain strength characteristics as intended by the designer. The complexity of the lay-up task means that it is normally done by hand, especially when making parts that have been highly optimised and have complex lay-up requirements. Laying up the sheets by hand is expensive, leads to inconsistency in the resulting products, and can be unpleasant for the workers due to irritations from stray carbon fibres and other chemicals that are used in the process.

Each sheet of material has a desired shape. These sheets are generally cut out of a larger piece of material to have the desired shape. This can generate significant amounts of waste material as the larger piece of material needs to be big enough that the whole of the desired shape can fit inside of it. In addition, there is a risk that the shape may not be cut accurately from the larger piece of material again leading to inconsistency in the resulting products.

Both of the problems described above cause difficulties when producing articles that are made by joining together multiple pliable sheets of material. These problems lead to discomfort for the workers, expense and variability in the final product. Similar problems arise in other areas. For instance, in garment manufactures and sail making it is common for individual piece of fabric to be assembled by hand and then stitched or fused together.

It would therefore be desirable for there to be an improved way of laying up sheets of material.

According to a first aspect of the present invention there is provided a tape deposition head for applying lengths of tape to a deposition surface, the tape deposition head comprising: a tape cutter having a tape inlet and a tape outlet, the tape cutter comprising: a feed roller configured to drive the tape though the tape cutter from the tape inlet to the tape outlet along a tape path; a nip roller acting against the feed roller to press the tape against the feed roller; and a tape slicer, the tape slicer having a blade for cutting the tape into lengths, the tape slicer being positioned between the feed roller and the tape outlet along the tape path; and a tape conveyor positioned at the tape outlet, the tape conveyor comprising: a deposition roller remote from the tape outlet; a capture roller; and a belt that runs between the capture roller and the deposition roller, the capture roller being positioned proximal to the tape outlet so that tape exiting the tape outlet contacts the belt, the belt being configured to move a cut length of tape to the deposition roller for deposition of the length of tape on to the deposition surface.

The tape cutter may comprise a feed roller drive motor to cause the feed roller to rotate and drive the tape through the tape cutter. The nip roller may be biased towards the feed roller to act against the feed roller.

The tape slicer may comprise an arm rotatably mounted to the tape cutter and the blade may be mounted to the arm. The tape slicer may comprise two blades mounted to the arm at equal distances from the rotation axis of the arm.

The tape cutter may comprise a cutting surface against which the blade forces the tape to cut the tape into the length of tape. The deposition roller may be located proximal to a transit path of the deposition surface past the tape deposition head.

The belt may be configured to move the cut length of tape to the deposition roller along a capture surface of the tape conveyor; and the tape conveyor may comprise a vacuum chamber, the vacuum chamber may generate a vacuum along the capture surface to hold the length of tape to the belt. The vacuum chamber may generate a vacuum around part of the deposition roller.

The tape deposition head may comprise a glue spray configured to spray glue towards the belt so that glue is deposited on to a length of tape moving along the belt towards the deposition roller.

The tape deposition head may comprise an air outlet positioned within the deposition roller to generate an air jet that forces the length of tape from the belt towards the deposition surface. The tape deposition head may comprise a compressed air source connected to the air outlet to generate the air jet. The vacuum may be generated around the part of the deposition roller that contacts the belt before the air jet in the motion direction of the length of tape.

The present invention will now be described by way of example with reference to the accompanying drawings. In the drawings:

Figure 1 shows a schematic side view of a tape deposition system.

Figure 2 shows a schematic side view of a tape cutter of the tape deposition system.

Figure 3 shows a schematic perspective view of the tape deposition system.

Figure 4 shows a schematic perspective view of a deposition platform.

Figure 5 shows a schematic view of a track system for the deposition platform.

Figure 6 shows a schematic perspective view of the tape deposition system comprising multiple deposition heads and a platform management system.

Figure 7 shows schematic views of a first example of components of the platform management system.

Figure 8 shows a schematic view of a second example of components of the platform management system.

The following description is presented to enable any person skilled in the art to make and use the invention, and is provided in the context of a particular application. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art.

The general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present invention. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

The present invention relates to a tape deposition head for applying lengths of tape to a deposition surface. The tape deposition head comprises a tape cutter having a tape inlet and a tape outlet. The tape cutter comprises a feed roller configured to drive the tape though the tape cutter from the tape inlet to the tape outlet along a tape path. The tape cutter comprises a nip roller acting against the feed roller to press the tape against the feed roller. The tape cutter comprises a tape slicer, the tape slicer having a blade for cutting the tape into lengths, the tape slicer being positioned between the feed roller and the tape outlet along the tape path. The tape deposition head further comprises a tape conveyor positioned at the tape outlet. The tape conveyor comprises a deposition roller remote from the tape outlet. The tape conveyor comprises a capture roller. The tape conveyor comprises a belt that runs between the capture roller and the deposition roller, the capture roller being positioned proximal to the tape outlet so that tape exiting the tape outlet contacts the belt, the belt being configured to move a cut length of tape to the deposition roller for deposition of the length of tape on to the deposition surface.

Figure 1 shows a tape deposition system 1. The tape deposition system 1 comprises a frame 2 to which components of the tape deposition system 1 are mounted. Other components of the tape deposition system 1 may be separately supported. For instance, components may stand on a floor that the frame also stands on. For at least some of the components of the tape deposition system 1 the spatial positioning of the components is important. In this case it can be advantageous if the components are mounted to the frame or connected to it so that their relative positioning can be maintained.

The tape deposition system 1 comprises at least one reel 3 of tape 4. The tape 4 is wound around a spool 5. The tape 4 is wound around the spool 5 along the length of the tape. The width of the tape runs across the spool 5 in the axial direction of the spool 3. The tape 4 may be a fibre tape. The tape 4 may comprise carbon fibres. The tape may be a carbon fibre tape. A carbon fibre tape may comprise carbon fibres weaved into a mat. The carbon fibre tape may be constituted solely of carbon fibre or alternatively may include other materials as well as the carbon fibre.

The tape deposition system 1 comprises a tape buffer 6 which stores a length of the tape 4 within the tape buffer 6. The tape buffer 6 provides tension to the tape 4 as it passes through the tape deposition system 1. The tape 4 runs from the reel 3 to the tape buffer 6. The tape buffer 6 comprises a plurality of upper rollers 7 and at least one lower roller 8. The upper and lower rollers 7, 8 run lengthways across the width of the tape 4. In this way the rotation axis of the rollers is substantially perpendicular to the feed direction of the tape 4. The lower rollers 8 are moveable relative to the upper rollers 7 to alter the distance between the upper rollers 7 and the lower rollers 8. The lower rollers 8 may be held in position by one or more weights 9 attached to the lower rollers 8. The lower rollers 8 may be attached to a mount that is attached to the one or more weights 9. The moveable nature of the lower rollers 8 provides tension to the tape 4. As the tape 4 is drawn out of the tape buffer 6 the lower rollers can move upward to provide the required length of tape to the downstream parts of the tape deposition system 1. Additional tape 4 may be drawn into the tape buffer 6 from the reel 3 of tape 4. It may be that the downstream components of the tape deposition system 1 require tape 4 to be provided at a higher speed for a period of time than can be unwound from the reel 3. In this case, the tape buffer 6 can provide the additional tape 4 by the movement of the lower rollers 8 for that period of time. Then, when the downstream components do not require tape 4 to be provided, additional tape 4 can be unwound from the reel 3 to replenish the tape buffer 6.

The tape deposition system 1 comprises a tape splicer 10. This permits the tape 4 from one reel 3 to be joined to a second reel of tape 4. This may be required to join the tape 4 from the first reel 3 that is almost empty to another tape 4 from the second reel to permit continuous deposition of tape 4 by the tape deposition system 1. The tape splicer 10 includes splicer rollers 11 to control the flow of tape 4 through the tape splicer 10. Tape splicer 10 comprises a fuser 12 to join the two tapes together. The tape 4 passes from the tape buffer 6 to the tape splicer 10 and then through tape splicer 10. As shown in figure 1, additional rollers may be present to guide the tape 4 from the tape buffer 6 to the tape splicer 10.

The tape deposition system 1 comprises a tape cutter 13. The tape cutter 13 slices the tape 4 into lengths which are captured in turn by tape conveyor 14 for the movement of the tape length to a deposition platform 15. The tape deposition system 1 comprises the tape conveyor 14 and deposition platform 15. The tape cutter 13 is shown in more detail in Figure 2.

The tape cutter has a tape inlet 28 and a tape outlet 29. The tape runs through the tape cutter from the tape inlet 28 to the tape outlet 29. The tape cutter 13 comprises a tape cutter body 24. The tape cutter 13 comprises a feed roller 20 rotatably mounted to the tape cutter body 24. The feed roller 20 has a rotational axis that is generally perpendicular to the feed direction of the tape 4. The feed roller 20 is coupled to a motor to drive the feed roller 20. The feed roller 20 may be selectively driven to feed tape 4 through the tape cutter 13. The feed roller 20 draws tape 4 from the tape buffer 6. The tape 4 runs over the feed roller 20 towards a rotatable slicer 21. To assist with the driving of the tape 4 by the feed roller 20, the tape cutter 13 comprises a pinch roller 25. The pinch roller 25 is located to press against the tape 4 from the opposite side of the tape 4 as feed roller 20. In this way, the tape 4 is located between pinch roller 25 and feed roller 20 and gripped between the two rollers. The pinch roller 25 is biased towards the feed roller 20 by a spring 26. The pinch roller 25 is mounted to tape cutter body 24.

The rotatable slicer 21 comprises at least one blade 22 attached to an arm 23. As pictured in Figure 2, the rotatable slicer 21 may comprise two blades 22 mounted to the arm 23. The blades 22 may be mounted to the arm 23 at equal distances from the rotation axis of the arm 23. The blades 22 may be mounted symmetrically about the rotatable slicer 21. The arm 23 is rotatably mounted to the body 24 of the tape cutter 13. The rotatable slicer 21 is coupled to a motor to drive the rotatable slicer 21. The arm may be coupled to the motor so that it can selectively rotate about its rotation axis.

As pictured in Figure 2, the two blades 22 may be mounted to the arm 23 at equal distances from the rotation axis of the arm 23 along a straight line running through the rotation axis of the arm 23. The blade(s) 22 have a cutting edge that is directed generally perpendicular to the rotation axis of the arm 23. The length of the arm 23 and the position of the blade(s) 22 is such that that the cutting edge of each blade 22 impinges on the tape 4 that projects from the feed roller 20 (and pinch roller 25 when present) towards tape conveyor 14 when the blade is at its closest to the tape 4. The impingement of the cutting edge on the tape 4 cuts the tape 4. The tape cutter 13 may comprise a cutting surface 27 against which the cutting edge of the blade forces the tape 4 to cut the tape 4. The cutting surface 27 may be a roller so that as the tape 4 is cut it moves towards the tape conveyor 14. The rotation of the arm 23 is controlled to cut the tape 4 to the desired length. The desired length of tape is fed by the feed roller 20 past the cutting surface 27 at which point the arm 23 is rotated to cause the blade 22 to cut the tape 4.

The tape cutter 13 may comprise an input roller 37 which is configured to guide the tape 4 into the tape cutter and on to feed roller 20. The input roller 37 is positioned to contact the tape 4 after it has entered the tape cutter 13.

The output of the tape cutter 13 is a length of tape 4. The length of tape is captured by the tape conveyor 14 for the movement of the tape length to the deposition platform 15. The tape conveyor 14 comprises a belt 16. The length of the belt 16 runs between the tape cutter 13 and an area above where the deposition platform 15 transits. The upper side of the belt runs directly between the tape cutter 13 and the deposition platform 15. The belt is orientated so as to run down from the tape cutter 13 to the deposition platform 15. The tape conveyor 14 comprises at least two rollers between which the belt 16 runs. A first conveyor roller 17, otherwise known as a capture roller 17, is located proximal to the tape cutter 13. The area of the belt 16 near the first conveyor roller 17 captures the cut length of tape from the tape cutter 13. A second conveyor roller 18, otherwise known a deposition roller 18, is located proximal to the transit path of the deposition platform 15. One of the first and second rollers may be driven by a motor to cause the belt 16 to move. The belt 16 is driven in an anti-clockwise direction as orientated in figure 1. The belt 16 is driven so that the tape moves along an upper surface of the belt 16 from the first conveyor roller 17 to the second conveyor roller 18. The upper surface of the belt 16 may be a capture surface of the tape conveyor 14. The length of tape is conveyed from the tape cutter 13 to the deposition platform by the capture surface of the tape conveyor 14. The upper surface of the belt 16 is defined by the region of the belt 16 that faces upwards for the collection of the length of tape 4 at any given movement.

The tape conveyor 14 may comprise a third roller in contact with the belt away from the capture surface of the tape conveyor 14. The third roller 19 may tension the belt 16. The third roller 19 may be mounted on a resilient biasing device such as a spring to push against the belt 16 to tension the belt 16. The third roller 19 may be driven by a motor to cause the belt 16 to move around the length of the belt 16.

The tape conveyor 14 comprises a vacuum chamber 30. The vacuum chamber 30 is connected to a pump to draw air from the vacuum chamber 30 to create an area of lower air pressure than in the surrounding space. The vacuum chamber 30 comprises an interface in the face of the vacuum chamber 30 that faces the capture surface of the tape conveyor 14. The interface causes a lower air pressure to be formed on the surface of the belt in the capture surface than in the surrounding air. This lower air pressure causes the lengths of tape to be pulled against the belt 16 along the capture surface. The interface may be a series of holes in the surface of the vacuum chamber 16 that faces the belt 16 along the capture surface.

The vacuum chamber 30 may be configured to generate a higher vacuum (i.e. a lower relative air pressure) towards the deposition roller 18 end of the belt 16 and a lower vacuum (i.e. a higher relative air pressure) towards the first conveyor roller 17 end of belt 16. The variable level of vacuum may be configured by the size and number of holes in the surface of the vacuum chamber 30 that faces the capture surface of the tape conveyor 14.

Tape conveyor 14 may run at a constant speed. In this way the belt 16 moves around the rollers 17, 18, 19 at a constant speed. The vacuum chamber 30 pulls the tape 4 onto the belt 16. However, until the tape cutter 13 cuts the length of tape 4 the tape 4 cannot move with the belt 16. Therefore, the tape 4 slips over the belt 16. It can be advantageous to have a variable level of vacuum produced by the vacuum chamber 30 and preferably a lower vacuum being produced at the end of the vacuum chamber closest to the tape cutter 13. This means that the vacuum chamber 30 does not pull the tape 4 on to the belt 16 too tightly before cutting occurs. This avoids damaging and/or stretching the tape 4. Once the tape 4 has been cut into a length of tape 4 then it is desirable for the length of tape 4 to be held tightly against the belt 16 as it is transferred to the deposition platform 15. Therefore, a higher vacuum towards the deposition platform 15 end of the belt 16 it preferable as it means that the length of tape 4 is held in position.

The tape deposition system 1 comprises a glue spay 31. The glue spray 31 is supplied with glue from a glue supply 32. The glue supply 32 may pump the glue along a pipe 33 to the glue spray 31. The glue spray 31 is positioned to deposit glue on to the length of tape 4 whilst the length of tape 4 is located on the belt 16. The glue spray 31 may be located to spay glue on to the length of tape 4 where the belt 16 contacts with the deposition roller 18. This ensures that the glue is deposited on to the length of tape 4 just before the length of tape 4 is deposited on to the deposition platform 15. The glue spray 31 may comprise an actuator to open a valve to permit the flow of pressurised glue from the glue pipe 33 to the glue spay 31 so that the glue spray 31 can spray glue on to the length of tape 4. The glue supply 32 may pressurise the glue being delivered to the glue pipe 33.

The tape deposition system 1 may be described as comprising a tape deposition head. The tape deposition head is configured to apply lengths of tape to the deposition surface 34 of the deposition platform 15. The tape deposition head may therefore comprise the parts of the tape deposition system 1 that cause the application of the lengths of tape 4 to the deposition platform 15. For instance, the tape deposition head may comprise the tape conveyor 14. The tape deposition head may comprise the tape cutter 13. The tape deposition head may be provided with tape by a tape supply. The tape supply may be configured to deliver a continuous length of tape to the tape deposition head. Thus, the tape supply may comprise the parts of the tape deposition system 1 that cause the delivery of tape to the tape deposition head. For instance, the tape supply may comprise the reel 3 of tape 4. The tape supply may comprise the tape buffer 6. The tape supply may comprise the tape splicer 11.

As discussed herein, the tape deposition system 1 comprises a deposition platform 15. The deposition platform 15 is runs around a track 32. In this way, the deposition platform 15 is moveable around a path. The deposition platform 15 is configured to run around the path in a first direction. The path is a loop. The first direction is chosen such that the deposition platform 15 runs past the tape conveyor 14 in the same direction as the belt 16 is moving around deposition roller 18. The movement of the deposition platform 15 past the deposition roller 18 is timed so that the start of the length of tape 4 is on the underside of the deposition roller 18 when the deposition platform 15 is moving underneath the deposition roller 18. This means that the length of tape 4 can be deposited on to a deposition surface of the deposition platform 15. The deposition surface may be an upper surface of the deposition platform 15. The deposition surface may equally be lengths of tape that have already been deposited on to the deposition platform 15 or may be a combination of the two.

The length of tape 4 is forced from the deposition roller 18 towards the deposition platform 15 by an air jet shown generally by 36. The air jet 36 may be fired from within deposition roller 18 if the deposition roller 18 is porous. The vacuum provided by the vacuum chamber 30 ends just before the air jet 36. In this way, the length of tape 16 is secured to the belt 16 until the point that it is forced towards the deposition platform 15 by the air jet 36. The air jet 36 compresses the length of tape 4 on to the deposition surface 34 of the deposition platform 15. As glue has been applied to the underside of the length of tape 4, as orientated when the length of tape 4 is applied to the deposition surface 34, the tape 4 is adhered to the deposition surface 34. The air jet 36 may be advantageous because the deposition head does not need to be in direct contact with the deposition surface 34. There can be a spacing between the deposition head and the deposition surface 34 meaning that the system can accommodate variable thicknesses of material on the deposition surface 34 which depositing the next length of tape. The tape deposition system 1 comprises an air outlet from which the air jet 36 emanates. The air outlet may be located within the deposition roller 18. The tape deposition system may comprise a compressed air source to supply air to the air outlet to generate air jet 36. The compressed air source may be generated by the vacuum chamber 30 as a consequence of generating the vacuum.

Figure 3 shows a perspective view of the deposition system 1. In this figure, it can be seen that the length of tape 4 is applied to the deposition surface 34 as a strip of tape across the surface of the deposition surface 34 along the motion path of the deposition platform 15.

The deposition platform 15 may run around the track 32 multiple times so that multiple lengths of tape 4 can be applied to the deposition surface. As discussed herein, those lengths of tape 4 may overlap in areas that required multiple thicknesses of tape and/or tapes running in multiple directions. An example of a deposition surface 34 which had had multiple lengths of tape 4 applied to it is shown in figure 4 which shows a perspective view of the deposition surface 34. The deposition platform 15 may be capable of rotating relative to its motion direction so that the lengths of tape 4 can be applied in selected directions across the deposition surface 34. The deposition platform 15 may be capable of moving in a transverse direction relative to its motion direction so that the lengths of tape 4 can be applied at selected offsets from each other. The rotation and offset of the deposition platform 15 may be continuously variable between defined end points. The rotation may be such that lengths of tape 4 can be applied to the deposition platform at any rotational angle.

Whilst only one deposition platform 15 has been described in relation to figures 1 to 4, the tape deposition system 1 may comprise a plurality of deposition platforms 15 that run around the track 32. A length of tape can be applied to each deposition platform 15 as it passes the deposition roller 18. This means that for each transit of the deposition platform 15 around the track multiple articles can be built up across the plurality of deposition platforms 15 that run around the track 32.

One example system of how the deposition platform 15 may be caused to rotate is shown in figure 5. This figure shows a perspective view of the track 32 and a plurality of deposition platforms 15. Each deposition platform 15 has a carriage 40 associated with it. The carriage 40 bears the deposition platform 15 and carries it around track

32 so that the deposition platform 15 moves around its motion path. The carriage 40 is caused to move around the track 32 by a first linear motor. The track 32 may comprise one side of the first linear motor and the carriage 40 may comprise the other side of the first linear motor. The first linear motor may be able to selectively move each carriage 40 along the track 32. The selective movement may be by selectively energising and de-energising the first linear motor. The carriage 40 may be driven around the track 32 using any suitable means. For instance, as an alternative example, each carriage 40 may comprise an electric motor which drives a wheel that contacts with the track 32 to drive the carriage 40 around the track 32.

As discussed herein, the deposition platform 15 may be caused to rotate about an axis perpendicular to the deposition surface 34 so that tape can be deposited on to the deposition surface 34 along selected directions. The deposition platform 15 may be pivotally attached to the carriage 40 to permit the deposition platform 15 to rotate about an axis perpendicular to the deposition surface 34. The deposition platform 15 may be driven about the rotation axis to cause the deposition platform 15 to rotate.

The deposition platform 15 may be driven using any suitable means. For instance, the carriage may comprise an electric motor which is coupled to the deposition platform 15 to cause it to rotate about the rotation axis. In another example, as shown in figure 5, the tape deposition system 1 may comprise a second track 41 that follows a second path. The second track 41 may run along a second path offset from the first path that the first track 32 follows. As shown in figure 5, the offset may be a horizontal and vertical offset. However, the offset may be just horizonal or vertical. A mover 42 is connected to the second track 41. The mover 42 is connected to the deposition platform 15 to control the rotational position of the deposition platform 15 around the rotation axis.

The mover 42 may be connected to an arm that is attached to the deposition platform 15 at a position offset from the rotation axis so that a relative movement of the mover 42 relative to the carriage 40 associated with a particular deposition platform 15 causes the deposition platform 15 to rotate about the rotation axis. In an alternative example, as shown in figure 5, the deposition platform 34 may be attached to an axle 42 that is rotationally connected to the carriage 40. The axle 42 may comprise a wheel

43. The mover 42 contacts the wheel 43 so that a relative motion of the mover 42 relative to the carriage 40 causes the mover 42 to rotate the wheel 43. The rotation of the wheel 43 causes the deposition platform 34 to rotate about the rotation axis.

The mover 42 may be driven around the second track 41 using any suitable means. For instance, each mover 42 may comprise an electric motor which drives a wheel that contacts with the second track 41 to drive the mover 42 around the second track 41. In another example, as pictured in figure 5, the mover 42 is caused to move around the second track 41 by a second linear motor. The second track 41 may comprise one side of the second linear motor and the mover 42 may comprise the other side of the second linear motor. The second linear motor may be able to selectively move each mover 42 along the second track 41. The selective movement may be by selectively energising and de-energising the second linear motor.

As discussed herein, the deposition platform 15 may be configured to move laterally relative to its motion path. For instance, the deposition platform 15 may be mounted to a rack and the carriage 40 may comprise an electric motor to drive the rack to cause the deposition platform 15 to move laterally relative to its motion path.

Whilst only one tape deposition head has been described in relation to figures 1 to 5, as shown in figure 6 the tape deposition system 1 may comprise a plurality of tape deposition heads 50 configured to apply lengths of tape to the deposition surface(s). The plurality of tape deposition heads 50 are positioned so that they can each apply lengths of tape to the deposition surface as the deposition platform passes under the tape deposition heads 50. The plurality of tape deposition heads may all each be able to apply lengths of tape to the deposition surface as the deposition platform passes under the respective tape deposition heads.

As shown in figure 6, the plurality of tape deposition heads 50 may be arranged in banks. The tape deposition heads 50 may be arranged into a single bank. The tape deposition heads 50 may be arranged into multiple banks. There may be two or more banks. As shown in figure 6, there may be three banks. Within each bank the tape deposition heads 50 may be aligned laterally so that each deposition head deposits a length of tape that runs parallel to the other lengths of tape but that have a longitudinal centreline that is offset from each other in the lateral direction. The lengths of tape from each of the deposition heads 50 may be deposited so that there is no or a minimal gap between the lengths of tape applied by a bank of deposition heads 50. In one example, twenty deposition heads may be arranged in a bank one beside the other. In another example, two banks of deposition heads may comprise ten deposition heads each. The two banks may be offset from each other in the deposition direction as described herein.

Where the tape deposition heads 50 are arranged in multiple banks, at least some of the tape deposition heads 50 in one bank may be aligned along the deposition direction with at least some of the tape deposition heads 50 in another bank. Where the tape deposition heads 50 are arranged in multiple banks, all of the tape deposition heads 50 in one bank may be aligned along the deposition direction with a tape deposition head in another bank. In another option, the tape deposition heads 50 in one bank may be offset from the tape deposition heads 50 in another bank so that their deposition directions are offset from each other in a direction perpendicular to the deposition direction.

The tape deposition system 1 may comprise a platform management device 51. The platform management device 51 is configured to move the deposition platforms 15 between a deployed position where the deposition platform 15 is able to run around the path and a storage location 52. The platform management device 51 may be configured to move the deposition platforms 15 between their respective carriages 40 and the storage location. The deposition platforms 15 may be keyed on their underside and the carriages 40 may have an opposite keying so that the deposition platform 15 can lock to the carriage 40 when deployed by the platform management device 51 on to the carriage 40.

One example of the platform management device 51 is shown in figures 6 and 7. Figure 6 shows the platform management device 51 comprising a storage location 52. The storage location 52 is capable of storing one or more deposition platforms 15. As shown in figure 6, the storage location 52 is capable of storing a plurality of deposition platforms 15 at any one time. The storage location 52 may comprise a series of shelves 53. A deposition platform 15 may be placed on to a shelf 53 for storage. The platform management device 51 comprises an unloading conveyor 54 to move the deposition platforms from a deployed position to the storage location 52. The platform management device 51 comprises a loading conveyor 55 to move the deposition platforms 15 from the storage location 52 to a deployed position. The loading and unloading conveyor may be joined together so that a deposition platform 15 placed on the combined conveyor from the storage location 52 moves towards a deployed position and a deposition platform 15 placed on the conveyor from being in a deployed position moves towards the storage location 52.

Figure 7 shows one example system for deploying and removing the deposition platforms 15 from the motion path (e.g. the on and off of track 32). The platform management device 51 may comprise a moveable portion 60 to one or both of the loading and unloading conveyors 55, 54.

The moveable portion 60 is usually positioned in the raised position shown in figure 7a so that is does not interfere with the motion of the deposition platforms 15. For the unloading process, the moveable portion 60 is located over the track 32 so that when the moveable portion 60 is in a lowered position the moveable portion 60 crosses the motion path (as shown by arrow 61) of the deposition platforms 15. This is as shown in figure 7b. The deposition platform 15 behind the moveable portion 60 in the motion direction 16 comes into contact with the moveable portion 60 when is the moveable portion 60 is in the lowered position. The deposition platform 15 is then dragged up on to the unloading conveyor 54 and the moveable portion 60 moved to the raised position so as not to impinge on any other deposition platform 15 moving around the track 32. This is as shown in figure 7c. In this way, a deposition platform 15 can be removed from the track. For the loading process, the movable portion 60 can be used in reverse. The moveable portion 60 lowers to deposit a deposition platform 15 on to the carriage 40 and then raises before the next deposition platform 15 passes the moveable portion 60.

An alternative example for deploying and removing the deposition platforms 15 from the motion path (e.g. on and off of track 32) is shown in figure 8. The platform management device 51 may comprise the components as described with relation to figure 6. However, in addition the platform management device 51 may comprise one or more moveable arms 70 to move the deposition platforms 15 between the storage location 52 and/or the loading and unloading conveyors 55, 54. The moveable arms 70 are moveable between a position where a grabbing head 71 overlays the deposition platform 15 whilst the deposition platform 15 is on the track 32 and a position where the grabbing head 71 overlays storage location 52, or, as pictured in figure 8, overlays at least one of the loading and unloading conveyor 55, 54. The grabbing head 72 comprises a device for selectively attaching itself to the deposition platform 15. The device may be one or more suction cups. The platform management device 51 may comprise at least one moveable arm 70 that moves platforms to the unloading conveyor 54 and at least one moveable arm 70 that moves platforms from the loading conveyor 55.

The platform management device 51 may comprise a combination of moveable portions 60 and moveable arms 70.

The tape deposition system 1 may comprise a controller 35. The controller 35 may be connected to the components of the tape deposition system 1 to control those components as described herein to deposit lengths of tape on to the deposition surface and manage the deposition platforms. The controller 35 may comprise a processor and a non-volatile memory. The controller may comprise more than one processor and more than one memory. The memory stores a set of program instructions that are executable by the processor, and reference data such as look-up tables that can be referenced by the processor in response to those instructions. The processor may be configured to operate in accordance with a computer program stored in non-transitory form on a machine-readable storage medium. The computer program may store instructions for causing the processor to issue instructions to control the components of the tape deposition system 1 in the manner described herein.

The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. A tape deposition head for applying lengths of tape to a deposition surface, the tape deposition head comprising:

a tape cutter having a tape inlet and a tape outlet, the tape cutter comprising: a feed roller configured to drive the tape though the tape cutter from the tape inlet to the tape outlet along a tape path; a nip roller acting against the feed roller to press the tape against the feed roller; and a tape slicer, the tape slicer having a blade for cutting the tape into lengths, the tape slicer being positioned between the feed roller and the tape outlet along the tape path; and

a tape conveyor positioned at the tape outlet, the tape conveyor comprising: a deposition roller remote from the tape outlet; a capture roller; and a belt that runs between the capture roller and the deposition roller, the capture roller being positioned proximal to the tape outlet so that tape exiting the tape outlet contacts the belt, the belt being configured to move a cut length of tape to the deposition roller for deposition of the length of tape on to the deposition surface.

2. A tape deposition head as claimed in claim 1, wherein the tape cutter comprises a feed roller drive motor to cause the feed roller to rotate and drive the tape through the tape cutter.

3. A tape deposition head as claimed in claim 1 or 2, wherein the nip roller is biased towards the feed roller to act against the feed roller.

4. A tape deposition head as claimed in any preceding claim, wherein the tape slicer comprises an arm rotatably mounted to the tape cutter and the blade is mounted to the arm.

5. A tape deposition head as claimed in claim 4, wherein the tape slicer comprises two blades mounted to the arm at equal distances from the rotation axis of the arm.

6. A tape deposition head as claimed in any preceding claim, wherein the tape cutter comprises a cutting surface against which the blade forces the tape to cut the tape into the length of tape.

7. A tape deposition head as claimed in any preceding claim, wherein the deposition roller is located proximal to a transit path of the deposition surface past the tape deposition head.

8. A tape deposition head as claimed in any preceding claim, wherein the belt is configured to move the cut length of tape to the deposition roller along a capture surface of the tape conveyor; and the tape conveyor comprises a vacuum chamber, the vacuum chamber generating a vacuum along the capture surface to hold the length of tape to the belt.

9. A tape deposition head as claimed in claim 8, the vacuum chamber generating a vacuum around part of the deposition roller.

10. A tape deposition head as claimed in any preceding claim, the tape deposition head comprising a glue spray configured to spray glue towards the belt so that glue is deposited on to a length of tape moving along the belt towards the deposition roller.

11. A tape deposition head as claimed in any preceding claim, the tape deposition head comprising an air outlet positioned within the deposition roller to generate an air jet that forces the length of tape from the belt towards the deposition surface.

12. A tape deposition head as claimed in claim 11, the tape deposition head comprising a compressed air source connected to the air outlet to generate the air jet.

13. A tape deposition head as claimed in claim 11 or 12 as dependent on claim 9, wherein the vacuum is generated around the part of the deposition roller that contacts the belt before the air jet in the motion direction of the length of tape.

Amendment to the claims have been filed as follows

CLAIMS

1. A tape deposition head for applying lengths of tape to a deposition surface, the tape deposition head comprising:

a tape cutter having a tape inlet and a tape outlet, the tape cutter comprising: a feed roller configured to drive the tape though the tape cutter from the tape inlet to the tape outlet along a tape path; a nip roller acting against the feed roller to press the tape against the feed roller; and a tape slicer, the tape slicer having a blade for cutting the tape into lengths, the tape slicer being positioned between the feed roller and the tape outlet along the tape path; and

a tape conveyor positioned at the tape outlet, the tape conveyor comprising: a deposition roller remote from the tape outlet; a capture roller; a vacuum chamber; and a belt that runs between the capture roller and the deposition roller, the capture roller being positioned proximal to the tape outlet so that tape exiting the tape outlet contacts the belt, the belt being configured to move a cut length of tape to the deposition roller along a capture surface of the tape conveyor for deposition of the length of tape on to the deposition surface, the vacuum chamber generating a variable level of vacuum along the capture surface to hold the length of tape to the belt.

2. A tape deposition head as claimed in claim 1, wherein the tape cutter comprises a feed roller drive motor to cause the feed roller to rotate and drive the tape through the tape cutter.

3. A tape deposition head as claimed in claim 1 or 2, wherein the nip roller is biased towards the feed roller to act against the feed roller.

4. A tape deposition head as claimed in any preceding claim, wherein the tape slicer comprises an arm rotatably mounted to the tape cutter and the blade is mounted to the arm.

5. A tape deposition head as claimed in claim 4, wherein the tape slicer comprises two blades mounted to the arm at equal distances from the rotation axis of the arm.

6. A tape deposition head as claimed in any preceding claim, wherein the tape cutter comprises a cutting surface against which the blade forces the tape to cut the tape into the length of tape.

7. A tape deposition head as claimed in any preceding claim, wherein the deposition roller is located proximal to a transit path of the deposition surface past the tape deposition head.

8. A tape deposition head as claimed in any preceding claim, the vacuum chamber generating a vacuum around part of the deposition roller.

9. A tape deposition head as claimed in any preceding claim, the tape deposition head comprising a glue spray configured to spray glue towards the belt so that glue is deposited on to a length of tape moving along the belt towards the deposition roller.

10. A tape deposition head as claimed in any preceding claim, the tape deposition head comprising an air outlet positioned within the deposition roller to generate an air jet that forces the length of tape from the belt towards the deposition surface.

11. A tape deposition head as claimed in claim 10, the tape deposition head comprising a compressed air source connected to the air outlet to generate the air jet.

12. A tape deposition head as claimed in claim 10 or 11 as dependent on claim 8, wherein the vacuum is generated around the part of the deposition roller that contacts the belt before the air jet in the motion direction of the length of tape.

13. A tape deposition head as claimed in any preceding claim, wherein the vacuum chamber generates a higher vacuum towards the deposition roller end of the belt.

14. A tape deposition head as claimed in any preceding claim, wherein the vacuum chamber generates a lower vacuum towards the capture roller end of the belt.

Application No:	GB2016694.8	**Examiner:**	Heather Webber
Claims searched:	1 - 13	**Date of search:**	14 June 2021

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,E	1-4, 6, 7	WO2020/249898 A1 (CARBON AXIS) see especially fig 12 and corresponding description
X,Y	X =1, 2, 4, 7-9; Y=5, 6	US4285752 A (CAMSCO INC) see especially column 4 line 57-column 6 line 50 and figures
X,Y	X =1, 7, 8, 11, 12; Y=4-6	US3574040 A (GEN DYNAMICS CORP) see especially column 5 lines 32-column 7 line 66 and figures
Y	4-6	DE102007012608 A1 (EADS DEUTSCHLAND GMBH) see WPI abstract accession number: 2008-M49476 and figure 8, 9 especially

Categories:

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

Field of Search:

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

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

A41H; B29C; B32B; B65H

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

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
B29C	0070/38	01/01/2006
B65H	0035/04	01/01/2006