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Gerber et al.

[11] **3,841,187**

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[54] **METHOD AND APPARATUS FOR HOLDING SHEET MATERIAL**

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[73] Assignee: **Gerber Garment Technology, Inc.,** East Hartford, Conn.

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[21] Appl. No.: **282,554**

[52] **U.S. Cl.** ..... **83/451,** 83/465, 83/925 CC

[51] **Int. Cl.** **D06h 7/00,** B26d 1/10

[58] **Field of Search** ..... 83/374, 451, 465, 925 CC, 83/49; 112/235; 30/275, 273; 269/265–269

[56] **References Cited**

UNITED STATES PATENTS

1,147,960	7/1915	Mathewson	112/235
2,979,808	4/1961	Booth	269/266 UX
3,495,492	2/1970	Gerber et al.	83/925 CC
3,572,202	3/1971	Gerber et al.	83/925 CC

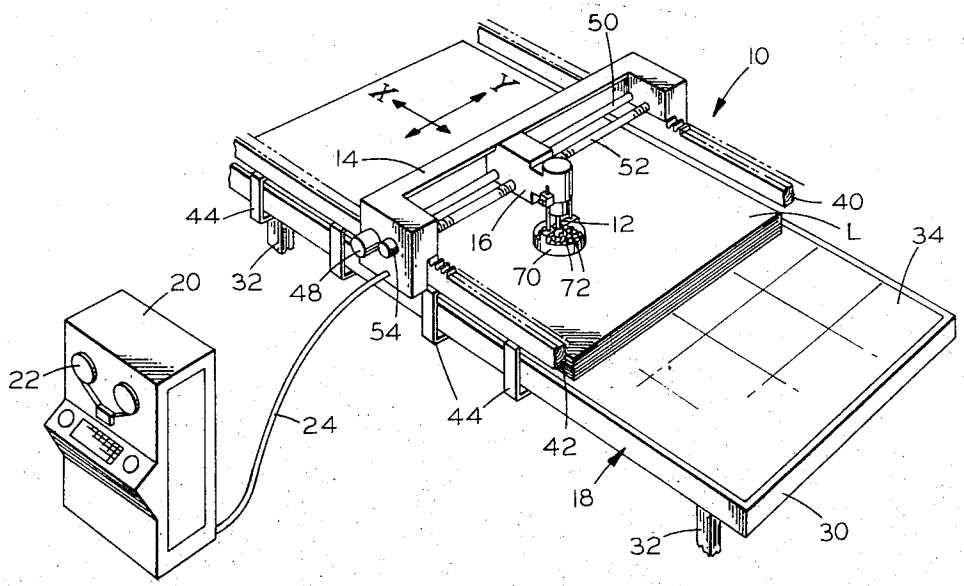
Primary Examiner—J. M. Meister

Attorney, Agent, or Firm—McCormick, Paulding & Huber

[57] **ABSTRACT**

The method and apparatus for holding sheet material while it is worked upon by a tool employ a support table having a surface on which the sheet material is spread and a cage which holds a plurality of spherical weights over a given portion of the sheet material. The weights rest either directly or indirectly on the material and press the material against the support surface. The spherical weights are held within the cage so that they rotate freely over the material when the cage is moved relative to the material. By connecting the cage to the carriage from which the working tool such as a cutting blade is suspended, the region of the sheet material which is subjected to the pressure of the spherical weights may be localized in that region which is immediately adjacent the tool and, accordingly, there is less opportunity for the sheet material to move or shift under the influence of the tool during the work operation.

5 Claims, 5 Drawing Figures



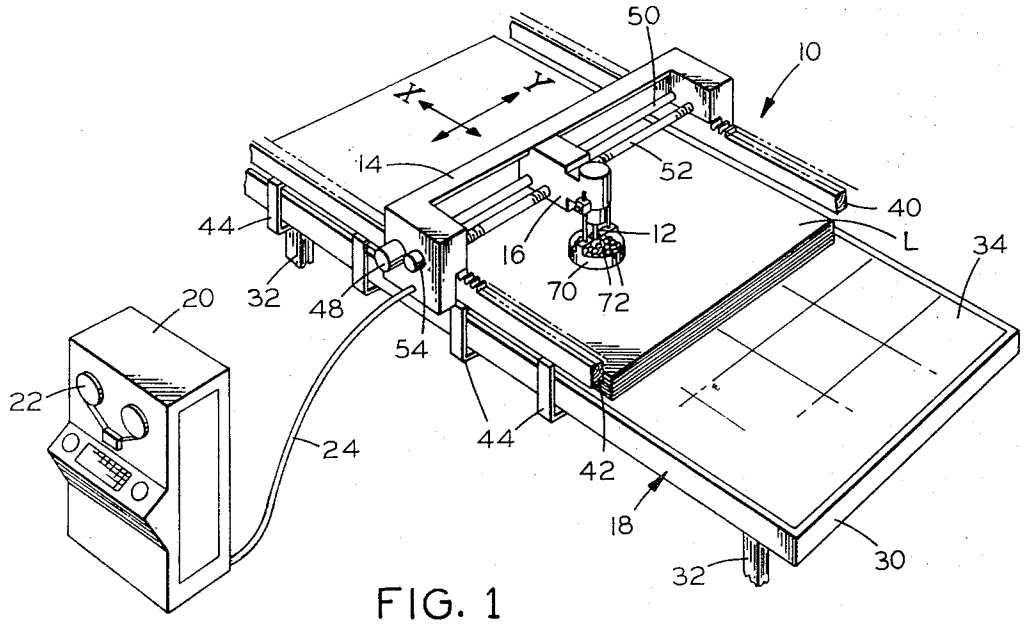


FIG. 1

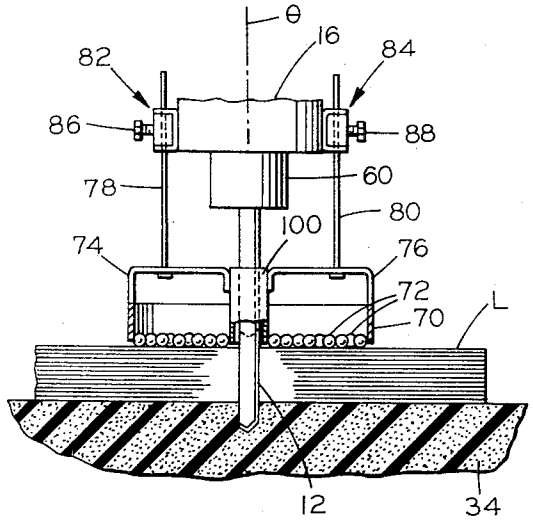


FIG. 2

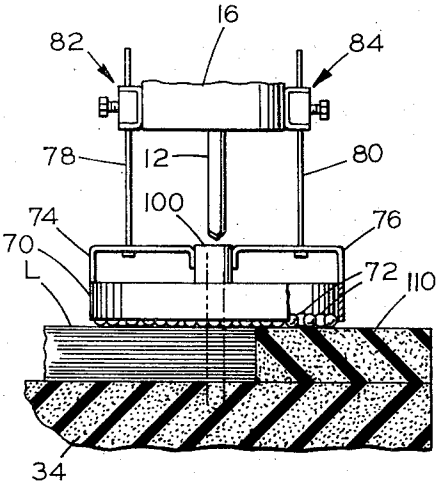


FIG. 3

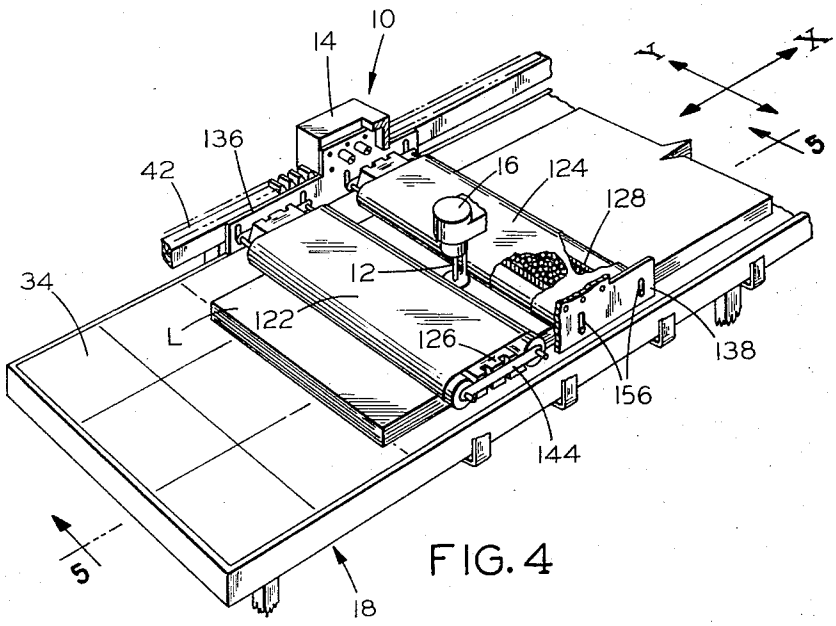

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FIG. 4

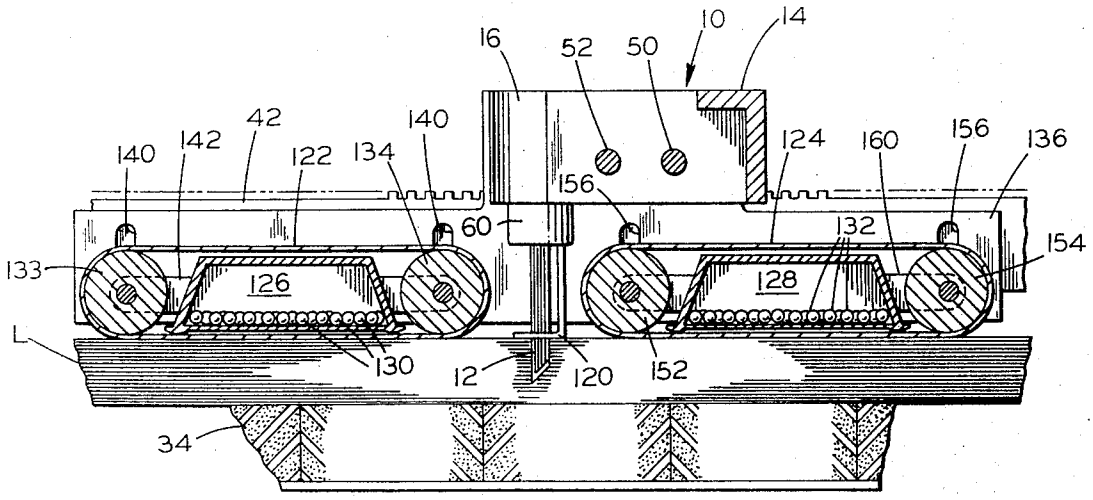

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FIG. 5

METHOD AND APPARATUS FOR HOLDING SHEET MATERIAL

BACKGROUND OF THE INVENTION

The present invention relates to method and apparatus for holding sheet material in a fixed and compressed condition against a surface on which the material is supported. More particularly, the invention is concerned with method and apparatus that employ a plurality of spherically shaped weights to hold limp sheet material, such as cloth or fabric material, while it is worked upon.

Materials such as cloth are spread in a multi-tiered layup on a work surface for cutting, notching, drilling or similar operations in which a tool generally plunges through each tier of the layup in perpendicular relationship to the sheet material forming the layup. If the material is particularly fluffy, it is desirable to compress the layup to a reduced height. With the material compressed, the distance through the layup which the tool must penetrate is reduced and a more uniform operation on the upper and lower tiers of the layup results. Compressed material also tends to be normalized, that is, materials having different degrees of fluffiness and different textures and shearing characteristics tend to react to a tool in a more uniform manner. Consequently, more uniform results can be expected when different materials are subjected to the same work operation. Also, by compressing the sheet material during an operation, there is less tendency for the sheet material to squirm or shift relative to the work surface on which it is supported or adjacent tiers of the material in a layup.

One apparatus for holding sheet material in a compressed condition during a cutting operation is shown in U.S. Pat. No. 3,495,492 having the same assignee as the present invention. The patent discloses a vacuum table on which the sheet material is compressed by generating a vacuum within the layup so that atmospheric pressure forces the material into a compressed condition against the supporting surface of the table.

Method and apparatus for holding sheet material on a work table and employing pressurized air to force the material onto the supporting surface of the table are disclosed in U.S. Pat. No. 3,750,507 issued on Aug. 7, 1973 to Heinz Joseph Gerber and David R. Pearl. A positive pressure or a pressure slightly above atmospheric pressure is generated immediately above a region of the sheet material adjacent the tool and holds the material in a compressed condition in much the same manner as the vacuum apparatus disclosed in the referenced patent.

Power driven rolls which translate over the top of a layup of sheet material to hold the material in a compressed condition while it is cut are disclosed in U.S. Pat. No. 3,693,489 issued Sept. 26, 1972 to David R. Pearl. The power driven rolls are carried adjacent a cutting blade so that the material in the vicinity of the cutting blade is held in a compressed condition while the cutting operation occurs.

The present invention may be used in conjunction with any of the above mentioned holding systems.

It is a general object of the present invention to disclose method and apparatus for holding sheet material in a compressed condition during a cutting or other work operation.

SUMMARY OF THE INVENTION

The present invention resides in method and apparatus for holding sheet material in a generally flat and compressed condition while it is worked on by a tool. The apparatus which operates in accordance with the method comprises support means, such as a flat table, defining a support surface for supporting a sheet material in a spread condition with one side of at least one sheet exposed. A plurality of spherically shaped and weighted bodies are positioned for free, rolling movement above the exposed side of the one sheet with the weight of the bodies supported by the sheet material. Caging means for capturing the weighted bodies in a closely packed relationship above a portion of the exposed side of the sheet material assures that the combined weight of the bodies is localized at a given region of the sheet material and holds that region compressed against the supporting surface of the table. in cutting layups of sheet material, the spherical bodies tend to compress the layup into a normalized condition and the caging means is connected to a drive means to cause the locally compressed region of the layup to move with and remain adjacent to the cutting tool as the sheet material is cut.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an automatic cloth cutting system employing the holding apparatus of the present invention.

FIG. **2** is a fragmentary cross-sectional view of the cutting mechanism in the FIG. **1** system and shows the freely rolling spherical weights and associated cage of the holding apparatus.

FIG. **3** is a fragmentary cross-sectional view of the cutting mechanism positioned adjacent the edge of a layup with the cutting blade withdrawn from operative engagement with the layup.

FIG. **4** is a perspective view of a cutting system employing an alternate embodiment of the holding apparatus.

FIG. **5** is a fragmentary sectional view of the cutting mechanism and the holding apparatus as viewed along the sectioning line **5—5** of FIG. **4.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** in a perspective view shows one embodiment of the holding apparatus of the present invention installed on an automatic cutting machine to hold a layup of cloth or other limp sheet material in position during a cutting or related work operation involving the sheet material. The particular material being cut may be a cloth, textile, plastic, foil or other pliable material and is held in a fixed position so that a predetermined line of cut can be accurately traversed in each ply of the layup by the cutting tool during the cutting operation. Although the holding apparatus is disclosed in a cutting machine, the apparatus has suitable applications in other mechanisms where the sheet material must not shift or be dislocated relative to either the supporting surface on which the material rests or the different plies of a layup formed by the sheet material.

The cutting machine, generally designated **10,** in FIG. **1** employs a cutting tool taking the form of a reciprocating cutting blade **12** which is supported by a pair of movable carriages **14** and **16** for movement over

a layup L of the sheet material spread on a support table **18.** A control computer **20** having a program tape **22** defining the paths or lines of cut to be followed by the blade **12** is connected to the carriages **14** and **16** by a control cable **24** to regulate the operation and the motions of the cutting blade **12** as it performs the cutting operation on the layup L. For example, where the layup L is composed of multiple sheets of cloth material stacked one upon the other on the table **18,** the program tape **22** may define cutting commands which are translated by the control computer **20** into signals recognized by the carriages **14** and **16** and other control components for the cutting blade **12** to cause the blade to cut out pattern pieces for wearing apparel, upholstery or other products.

The table **18** includes a frame **30** supported on a plurality of upright legs **32.** Within the frame **30** is a bed **34** that can be penetrated by the reciprocating cutting blade **12** without damaging the blade. The bed **34** may be formed by replaceable blocks of foamed plastic, bristle or other easily penetrated material and defines the support surface on which the layup L of sheet material is spread during the cutting operation.

The carraige **14,** referred to hereafter as the X carriage, travels back and forth over the support surface of the table **34** in the X coordinate direction indicated on the layup L. The X carriage **14** is supported above the bed **34** on gear racks **40, 42** connected to the frame **30** of the table **18** by a plurality of brackets **44.** An X drive motor **48** rotates a pair of pinions (not shown) engaged respectively with the racks **40** and **42** to cause the carriage to be driven back and forth in the longitudinal or X direction over the table **34.** Commands transmitted through the control cable **24** from the control computer **20** regulate the energization of the X drive motor **48** to position the carriage **14** and the blade **12** in the longitudinal direction during the cutting operation.

The carriage **16,** hereafter referred to as the Y carriage, is mounted to the X carriage **14** for movement in the transverse or Y coordinate direction relative to the X carriage **14** and the table **18.** Composite motions of the X and Y carriages permit the cutting blade **12** to move over the support surface of the bed **34** relative to the layup L so that lines of cut can be generated in any desired direction through the layup

The Y carriage **16** is supported on the X carriage **14** by means of a transversely extending guide rail **50** and a lead screw **52** threadably engaged with the carriage **16.** A Y drive motor **54** connects with the lead screw **52** to position the carriage **16** on the rail **50** and screw **52** and to correspondingly position the cutting blade **12** in the Y coordinate direction. The drive motor **54** is also regulated by the control computer **20** in accordance with commands derived from the program tape **22.**

To keep the cutting blade **12** tangent to or parallel with the line of cut during a cutting operation, it is rotated about the vertical or θ-axis relative to the Y carriage **16** as shown in FIG. **2** by a θ-drive motor (not shown) also regulated by the control computer **20.**

As shown more clearly in FIG. **2,** the cutting blade **12** is supported on the Y carriage **16** by a Z carriage **60** which is translatable relative to the Y carriage **16** along the vertical axis perpendicular to the support surface of the bed **34.** The elevating motions of the Z carriage **60** produced by a drive motor (not shown) also regulated by the control computer **20** cause the cutting blade **12** to be lowered into a cutting position relative to the layup as shown in FIG. **2** or raised away from the cutting position above the layup as shown in FIG. **3.** The motions of the Z carriage **60** should not be confused with the reciprocating motions of the blade **12** when the Z carriage is in the lower or cutting position. The reciprocating drive motor (not shown) is mounted to the carriage **60** for vertical movement with the cutting blade. The stroke of the cutting blade **12** is fixed by the drive linkage connecting the blade with the motor; however, when it is desired to cut the layup, the carriage **60** is lowered to the point indicated in FIG. **2** so that the blade **12** at the lower extreme of its reciprocation penetrates into the bed **34** and assures that the lowest ply of sheet material in the layup is cut. The upper and lower limits of the blade stroke are indicated in FIG. **2** by the solid-line and phantom positions of the bottom of the blade. When the carriage **60** is raised to its uppermost position indicated in FIG. **3,** the cutting blade is completely withdrawn from the layup and can be rapidly slewed to another cutting point over the layup.

With respect to the present invention, it will be noted in FIGS. **1, 2** and **3** that a cage **70** capturing a plurality of spherically shaped and weighted bodies **72** is suspended from the Y carriage **16** immediately adjacent the cutting blade **12.** The cage **70** comprises a circular member to which a pair of brackets **74** and **76** are connected. A pair of support rods **78** and **80** extend downwardly to the brackets **74** and **76** respectively from adjustable clamp assemblies **82** and **84** connected to the Y carriage **16.** A clamping bolt **86** locks the rod **78** in the clamp assembly **82** and clamping bolt **88** locks the rod **80** in the assembly **84.** The height of the cage **70** above the layup L is determined by the adjustment of the rods **78** and **80** in the assemblies **82** and **84** and is preferably selected at the beginning of each cutting operation to permit translation of the cage over the layup without touching the uppermost ply and without allowing the spherical bodies **72** to escape under the lower edges of the circular member.

The spherical bodies **72** are held loosely in the cage **70** and rotate freely relative to one another and to the cage **70** so that as the carriages **14** and **16** cause the knife **12** to be translated over the layup, the bodies **72** roll freely on the exposed surface of the uppermost ply in the layup. The entire weight of the bodies **72** is supported by the layup and, by forming the bodies as balls from a dense material, preferably a heavy metal such as steel having good wear characteristics, a circular region of the layup underlying the cage **70** and surrounding the cutting blade **12** is placed in compression. Accordingly, each ply of the layup L is exposed to a slight compressive force in a region surrounding the blade as the blade travels along a desired line of cut. Friction between each of the plies of sheet material in the region under pressure tends to prevent the plies from shifting relative to one another and relative to the bed **34.** Pattern pieces cut from the uppermost and bottommost plies of the layup, therefore, are more uniform in size and shape. Also, the weighted spherical bodies **72** prevent the upper plies of the layup from lifting during the upstroke of the reciprocating blade and thereby assist the cutting operation by holding the material fixedly adjacent the cutting edge of the reciprocating blade **12.**

In the embodiment of FIGS. 1–2, the brackets 74 and 76 support a knife sheath 100 at the center of the cage 70 and surrounding the blade 12. The sheath 100 is cylindrical and has an inside diameter which permits the blade to pass in closely spaced relationship with the inner surfaces of the sheath without touching the sheath and to be rotated about the θ-axis relative to the sheath. If desired, the sheath 100 may envelope a blade guide suspended from the carriage 60 in addition to the blade 12 itself and permit rotation of the guide with the blade about the θ-axis.

The sheath 100 permits the cutting blade 12 to be lowered from the raised position for slewing as shown in FIG. 3 to the cutting position shown in FIG. 2 without necessitating that the blade penetrate through the planar array of spherical bodies 72 captured within the cage 70 and permits the blade to reciprocate through and rotate freely in the array of bodies.

As shown in FIG. 3, it is desirable to position edge blocks 110 along each edge of the layup L so that the blade 12 can cut in close proximity to the edge of the layup without having the spherical bodies escape under the lower edge of the cage. The positioning of the carriage 16 and the blade 12 near the edge of the layup with the blade raised is typical of the configuration of the cutting machine at the beginning of a cutting operation. It is in this position after the layup L has been spread on the bed 34 that the spherical bodies 72 are initially installed in their freely rotatable condition within the cage 70. The sheath 100 and the cage 70 form an annular region overlying the layup and in which the spherical bodies 72 are confined. As the cutting blade 12 is translated relative to the layup L, the cage 70 suspended from the Y carriage 16 and the bodies 72 track the motions of the blade in both the X and Y coordinate directions.

FIGS. 4 and 5 disclose the cutting machine 10 with another embodiment of the holding apparatus which also employs a cage and a plurality of spherical bodies for holding a layup of sheet material in position while it is worked on by the reciprocating blade 12. The portions of the cutting machine in FIGS. 4 and 5 having corresponding portions in FIGS. 1–3 bear the same reference numerals. A presser foot 120 which surrounds the blade 12 in conventional fashion assists in the cutting operation by preventing the upper plies of the layup from being lifted during the upstroke of the blade.

In the embodiment of FIGS. 4 and 5, a pair of endless belts 122 and 124 are positioned at opposite longitudinal sides of the blade 12 and two cages 126 and 128 are mounted within the endless belts 122 and 124 respectively so that the plurality of spherical weights 130 and 132 in the respective cages are captured in planar rays and rest directly on that portion of the belts 122 and 124 in direct contact with the exposed surface of the layup L. The belts and the cages are suspended from the X carriage 14 so that the cutting blade 12 may move relative to the belts in the Y coordinate direction in the slot between the belts, and the belts move with the cutting blade in the X coordinate direction. Rotation of the blade 12 about the vertical or θ-axis is provided to orient the blade parallel to the direction of advancement in the X and Y directions.

The endless belt 122 is carried on a pair of rollers 133 and 134 and the rollers in turn have axles engaged by sideplates 136 and 138 connected respectively to opposite sides of the X carriage 14 for movement in the X coordinate direction. The side plates contain vertical slots 140 in which the axles of the rollers 133 and 134 are captured to permit the height of the endless belt above the work surface of the bed 34 to be adjustable and, more importantly, to permit the entire weight of the endless belt 122, the spherical weights 130, the rollers 133 and 134 and associated equipment to rest on the layup. Since the cage 126 is suspended slightly above the portion of the belt in contact with the layup by means of bracket plates 142 and 144 secured to opposite lateral ends of the cage and the axles on the ends of the rollers 133 and 134, the downward force on the layup through the belts includes the weight of the cage 126. The total weight of the spherical bodies 130, the cage 126, the rollers 133 and 134 and the endless belt 122 generates substantial pressure on the portion of the layup directly below the belt and adjacent the cutting blade 12 and significantly aids the cutting operation by compressing the sheet material and preventing it from shifting as the blade travels through the layup along a desired line of cut.

In a similar manner, the endless belt 124 is carried on a pair of rollers 152 and 154 each having axles captured in vertical slots 156 in the side plates 136 and 138. A pair of bracket plates 160 (one not visible) similar to the bracket plates 142 and 144 suspend the cage 128 from the axles of the rollers 152 and 154. It will thus be seen that the combined weight of the spherical bodies 132, the cage 128, the rollers 152 and 154 and the endless belt 124 rest on the layup at the side of the cutting blade opposite the endless belt 122. The combined downward forces transmitted through the belts to the layup at opposite sides of the cutting station produce substantially the same compression and holding effects as that obtained in the embodiment of FIG. 1 where the weighted bodies 72 captured within the cage 70 completely surrounded the cutting blade.

The rollers 133, 134, 152, and 154 may be driven in conjunction with the X drive motor 48 which moves the X carriage 14 longitudinally over the cutting table. Regardless of whether the rollers are powered or not, the motions of the cutting blade in the X coordinate direction will be accompanied by a corresponding movement of the endless belts 122 and 124 and the weighted bodies 130 and 132 to maintain the portions of the layup immediately adjacent the cutting blade in the compressed and held condition.

It will be noted with respect to the embodiment of the holding apparatus shown in FIGS. 4 and 5 that by mounting the cages within travelling belts which roll along the layup, the portions of the belts which are interposed between the layup and weighted bodies 130 and 132 prevent the bodies from dropping out of the cages into depressed areas or holes within or along the edges of a layup. In other words, the endless belts effectively hold the spherical bodies within the cages 126 and 128 and, at the same time, allow the weight of the bodies to act downwardly through the belts on the layup.

While the present invention has been described in several preferred embodiments, it will be understood that still further substitutions and modifications can be made without departing from the spirit of the invention. For example, it has already been mentioned above that the endless belts shown in the embodiments of FIGS. 4 and 5 may be either powered or free to roll

over the layup in the X direction with the cutting blade. The endless belts **122** and **124** and enclosed cages and weighted bodies can also be advantageously employed on cutting machines having movable tables formed by another set of endless belts underlying the layup and over which the layup is translated relative to the cutting blade. If desired, the compressive forces produced by the spherical bodies can be supplemented by drawing a vacuum in the layup or by adding a source of positive fluid pressure to the upper surface of the layup. The particular configurations of the cages disclosed in the preferred embodiments may, of course, be varied. The size of the spherical bodies is not particularly critical; however, if the bodies are too small, they may more easily escape from the cage and if they are tool large, they may not fit within the cage so that they rotate freely and produce a generally uniform downward pressure on the layup throughout that portion of the layup directly below the cage. Accordingly, the present invention has been described in a preferred embodiment by way of illustration rather than limitation.

We claim:

1. Apparatus for cutting sheet material comprising: support means defining a work surface on which sheet material is positioned during a cutting operation; a cutting tool suspended above the work surface and having a sharp cutting edge; movable carriage means connected to the tool and the support means for moving the cutting tool and the sheet material positioned on the work surface relative to one another back and forth in two coordinate directions parallel to the work surface and with the cutting edge engaging the material; control means connected to the movable carriage means for controlling the relative movement of the cutting tool and the support means to advance the cutting edge of the tool relative to the material along a desired line of cut; holding means positioned adjacent the cutting tool for applying pressure to the sheet material to cause the sheet material to be pressed against the work surface, the holding means including a cage suspended with the cutting tool above the work surface and circumscribing the tool and a plurality of spherical weights held in the cage in a closely packed planar array extending in both of the two coordinate directions and at each side of the cutting tool; and a sheath also suspended above the work surface within the periphery of the cage and interposed between the cutting blade and the array of spherical weights extending in the two coordinate directions to capture the weights in the region between the cage and the sheath and separate the cutting tool and weights during relative movement of the tool and sheet material in the two coordinate directions.

2. Apparatus for cutting sheet material as defined in claim **1** wherein the spherical weights of the holding means are metallic balls freely rotatable within the cage.

3. Apparatus for cutting sheet material as defined in claim **2** wherein the metallic balls are steel balls.

4. Apparatus for cutting sheet material as defined in claim **1** wherein: the movable carriage means comprises a first carriage movable over the work surface of the support means in a first of the two coordinate directions and a second carriage mounted on the first carriage and movable along the first carriage and over the work surface in a second of the two coordinate directions perpendicular to the first coordinate direction; the cutting tool is suspended from the second carriage for movement in each coordinate direction over the work surface; and the cage of the holding means and the sheath are also suspended from the second carriage adjacent the cutting tool for movement with the tool in each coordinate direction.

5. Apparatus for cutting sheet material as defined in claim **1** wherein: the support means comprises a support table defining the work surface on which the sheet material is positioned; the carriage means includes a carriage mounted on the support table and movable over the work surface in at least one coordiante direction; the cutting tool is suspended from the carriage; and the cage and the sheath are also suspended from the carriage for movement with the tool.

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