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Gerber et al.

[11] **3,750,507**

[45] **Aug. 7, 1973**

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

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

[22] Filed: **Dec. 9, 1970**

[21] Appl. No.: **96,384**

[52] **U.S. Cl.** ..... **83/169,** 83/374, 83/451, 83/747, 83/925 CC

[51] **Int. Cl.** **B26d 1/10,** B26d 7/02

[58] **Field of Search** ..... 83/169, 451, 374, 83/402, 22, 422, 431, 561, 145, 146, 111, 98, 99, 925 CC, 747; 269/20; 30/275; 112/235

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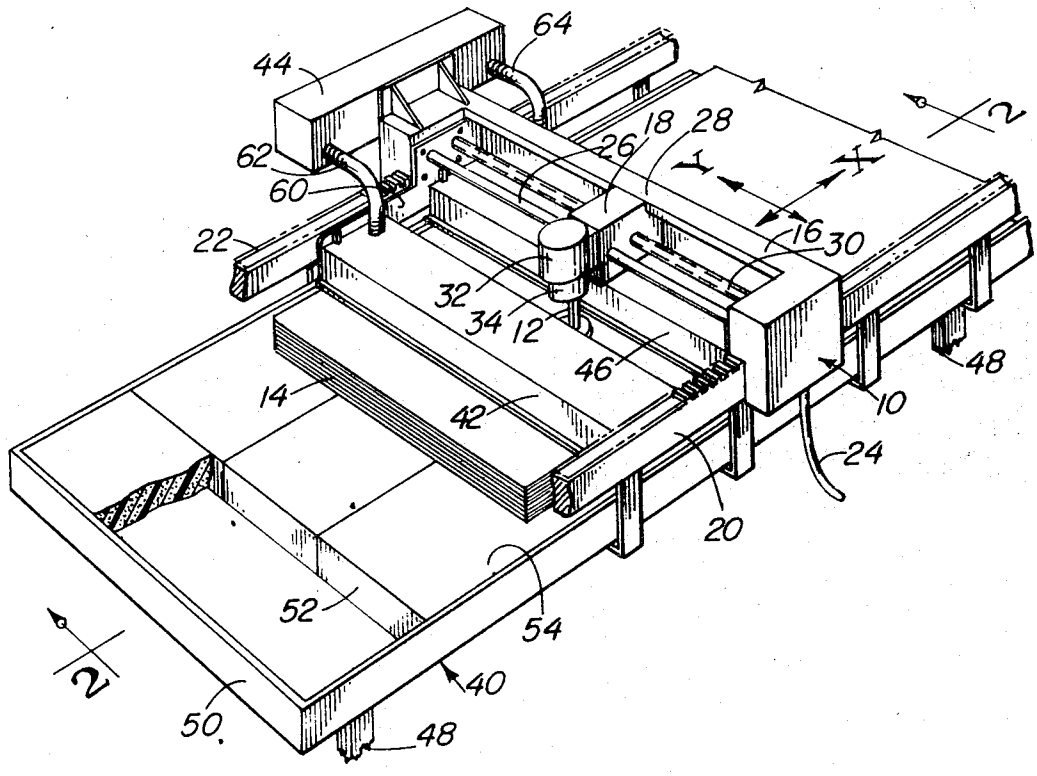
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Primary Examiner—J. M. Meister
Attorney—McCormick, Paulding & Huber

[57] **ABSTRACT**

A method and apparatus are disclosed for holding sheet material such as woven and non-woven fabrics, plastic or paper while the material is being worked upon by a tool which translates over the sheet material to perform a cutting, plotting or other material processing operation. The apparatus which holds the sheet material in a fixed position during the operation includes a table which supports the material as a single sheet or in a layup and a fluid compartment which is positioned over and exposes the material to pressurized air to force the material onto the supporting surface of the table. While maintaining a region of increased air pressure in the immediate vicinity of the tool, the compartment may be translated along one or two orthogonal directions in conjunction with the movements of the tool. The compartment is open or perforated at the side confronting the material to expose the material to the air under pressure within the compartment. When appropriate, a sheet of impervious material may be overlaid on a layup of the material to increase the effective pressure on each ply of the layup.

9 Claims, 13 Drawing Figures



Patented Aug. 7, 1973 3,750,507

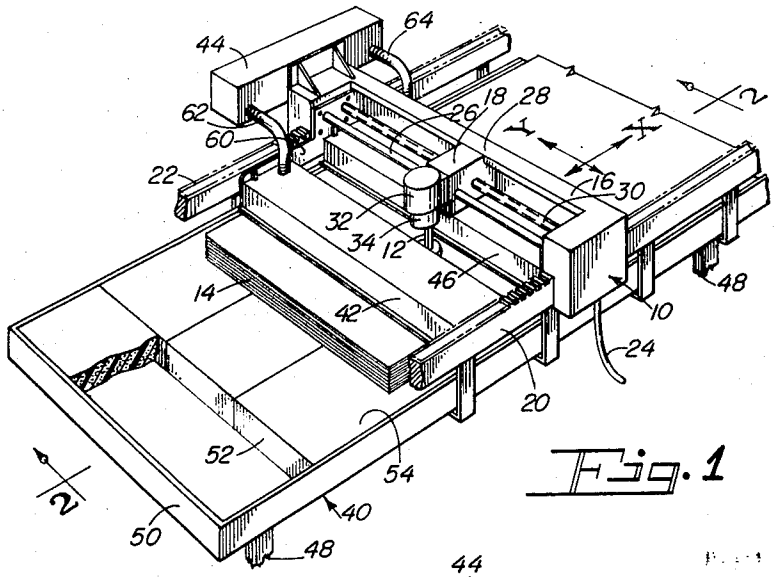


Fig. 1

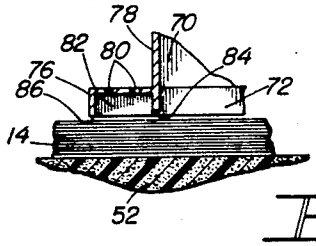


Fig. 4

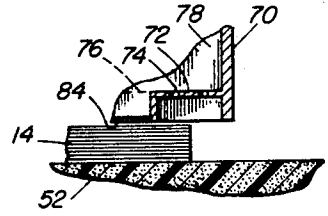


Fig. 5

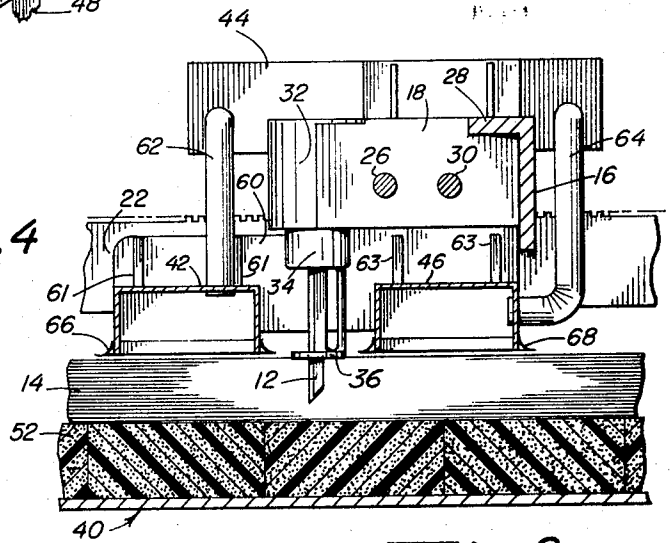


Fig. 2

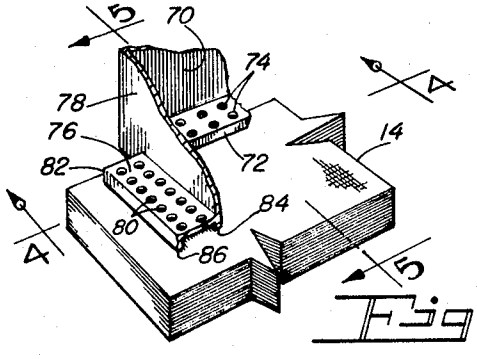


Fig. 3

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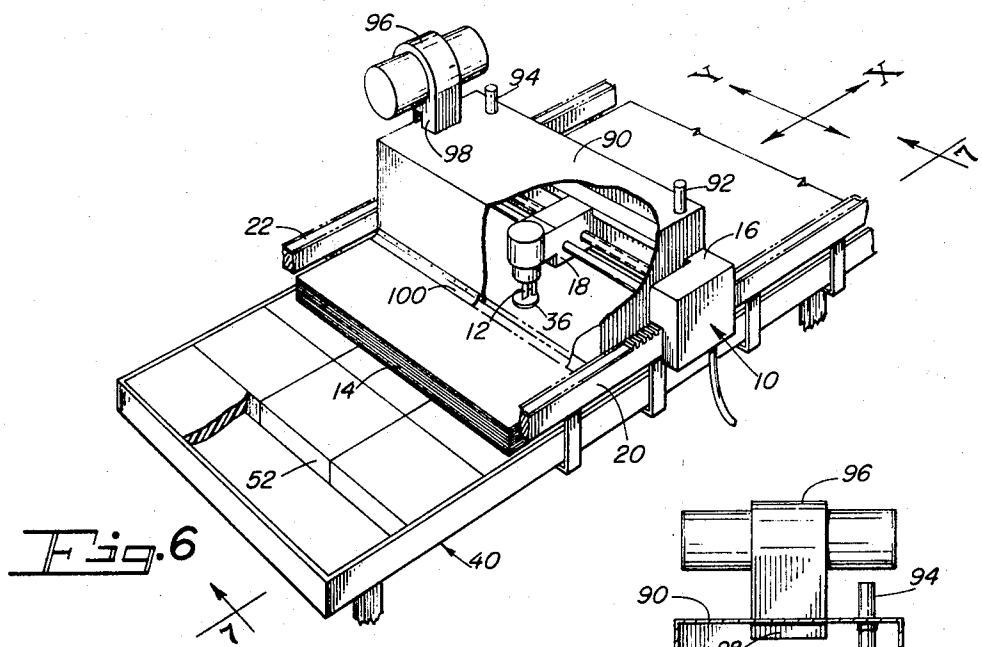


Fig. 6

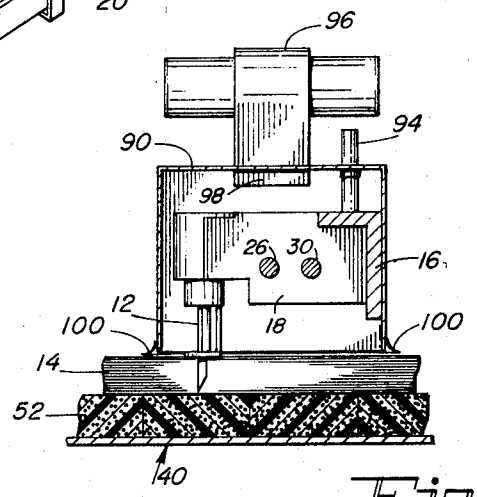


Fig. 7

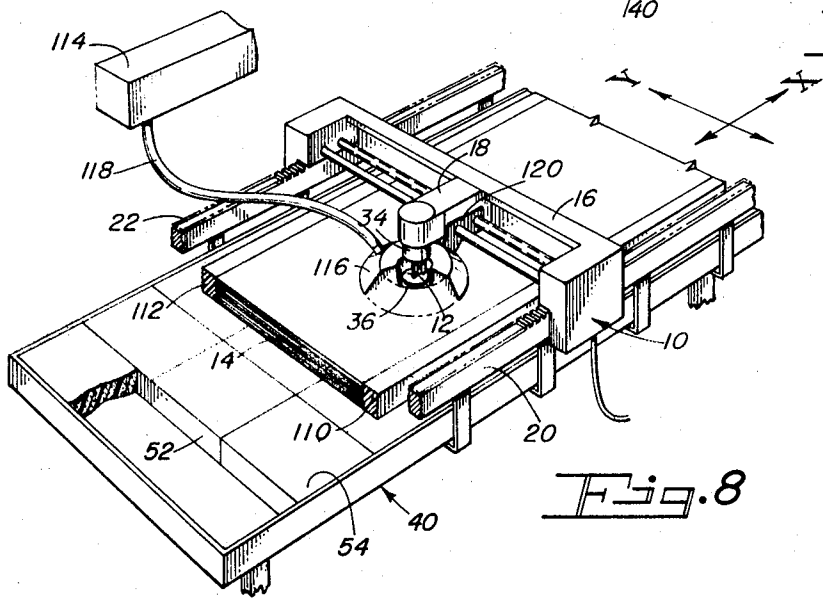


Fig. 8

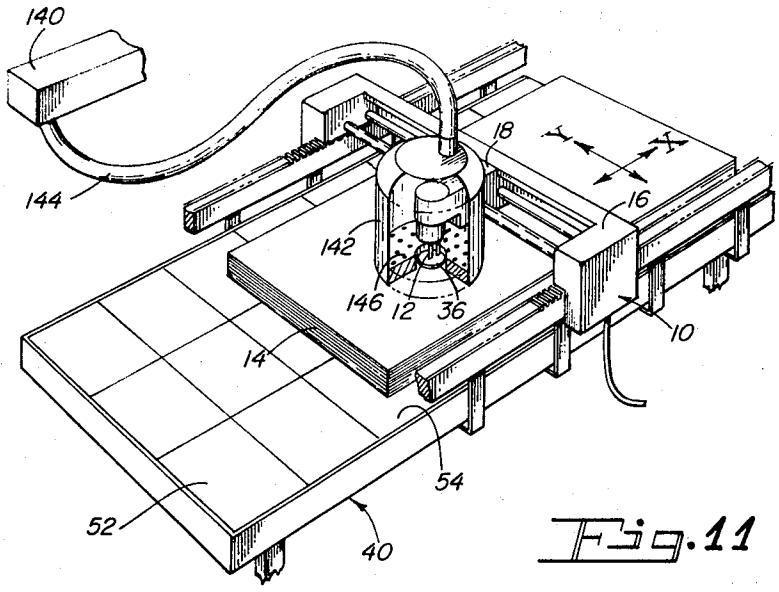


Fig. 11

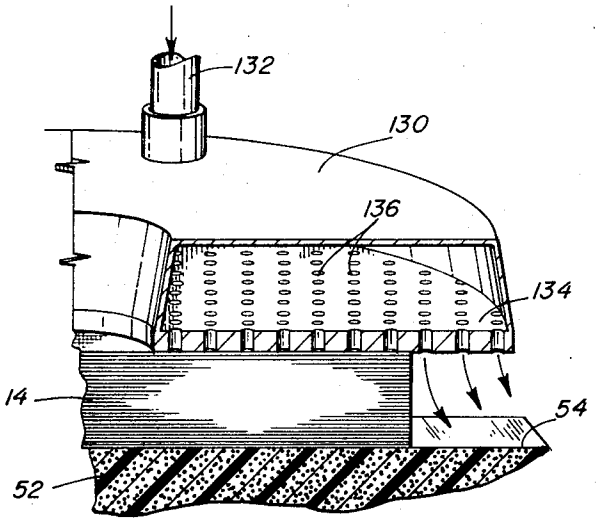


Fig. 10

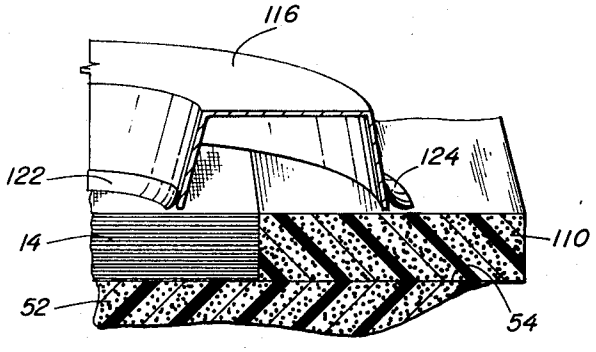


Fig. 9

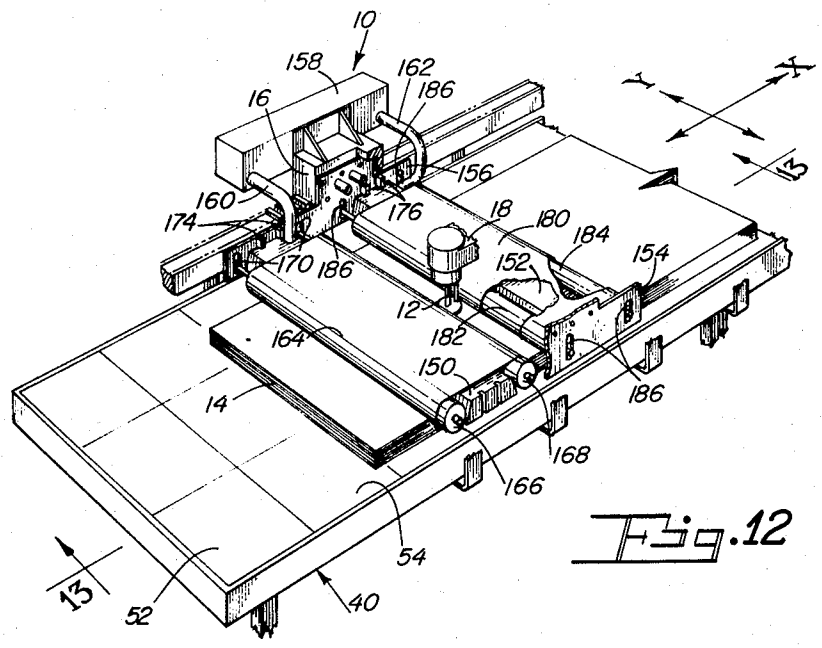

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Fig. 12

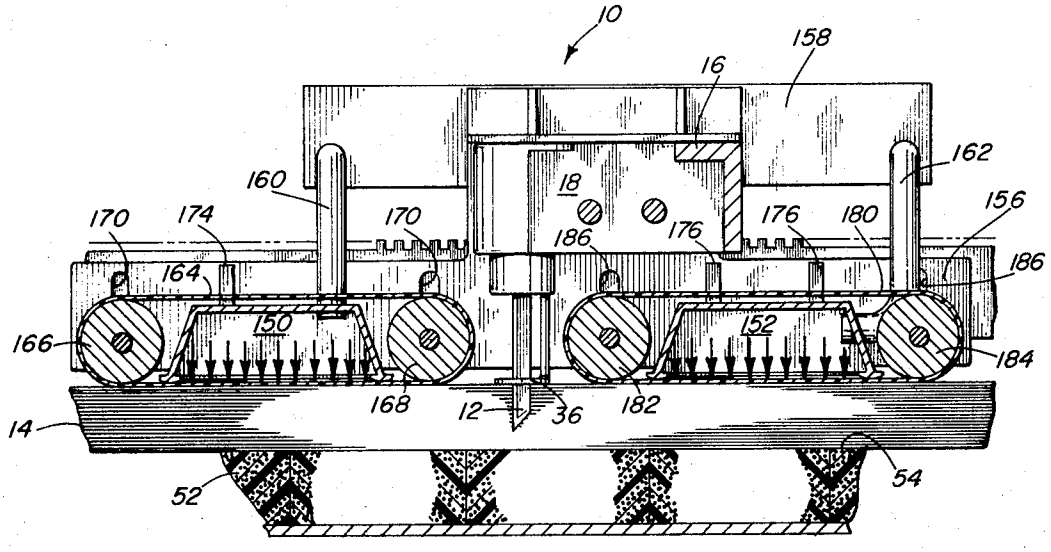

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Fig. 13

METHOD AND APPARATUS FOR HOLDING SHEET MATERIAL

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for holding sheet material in a fixed position while the material is worked upon by a tool.

In the past, it was customary to cut pattern pieces from a layup of sheet material formed by multiple plies of woven or non-woven fabric piled one upon the other by guiding a motor-driven, reciprocating knife by hand through the layup. To hold the layup in position during the cutting operation, the operator of the knife would use his free hand to press down on the layup at a point adjacent to the cutting path traversed by the knife.

More recent advances in the fabric cutting technology have brought into use mechanically guided cutting devices which are numerically controlled by a digital computer to cut pattern pieces from a layup according to a program on a punched tape or other memory device. Obviously, it is dangerous and not feasible for an individual to attempt to press a layup of sheet material against a table while the layup is cut by a computer controlled knife. Other means for pressing the different plies of the layup together must be employed so that a clean and accurate cut can be made without lifting or shifting of the fabric during the cutting process and so that a reciprocating knife penetrates a layup of nominal thickness along a substantially vertical path to cut pattern pieces of substantially identical shapes from the upper and lower plies of the layup. One such apparatus which performs this function by means of a vacuum hold-down device is disclosed in U. S. Pat. No. 3,495,492, issued Feb. 17, 1970, and entitled "Apparatus for Working on Sheet Material," and having the same assignee as the present invention.

The general aim of the present invention is to provide an improved method and apparatus of the aforedescribed type for holding sheet material in a fixed position while being worked upon by a device such as a numerically controlled tool.

SUMMARY OF THE INVENTION

The present invention resides in a method and apparatus for holding sheet material in a fixed position while the sheet material is worked upon by a tool, for example, a cutting tool which traverses the sheet material to cut out pattern pieces for garments and other articles. The apparatus, which also functions according to the novel method of the present invention, comprises means such as a table which defines a material supporting surface for supporting the sheet material in the fixed position and means for producing a region of increased fluid pressure above the supporting surface so that the fluid pressure may hold supported sheet material against the surface. The means for producing the region of increased pressure includes a fluid compartment which defines a fluid discharge opening in a portion of the compartment confronting the material supporting surface for exposing the sheet material to a fluid under pressure received in the compartment. In one embodiment of the invention, the fluid compartment generates a region of locally increased pressure above the sheet material supported on the surface and is provided with a positioning means to translate with a tool such as a cutting tool so that the region of increased pressure is maintained in the immediate vicinity of the tool.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a numerically controlled cutting device utilizing one embodiment of the present invention.

FIG. 2 is a sectional view of a portion of the cutting device as seen along line 2—2 in FIG. 1.

FIG. 3 is a fragmentary perspective view showing the detailed construction of a fluid compartment utilized in one embodiment of the present invention.

FIG. 4 is a fragmentary sectional view of the fluid compartment as seen along the line 4—4 in FIG. 3.

FIG. 5 is a fragmentary sectional view of the fluid compartment as seen along the line 5—5 in FIG. 3.

FIG. 6 is a perspective view of a cutting apparatus utilizing another embodiment of the present invention.

FIG. 7 is a sectional view of a portion of the cuttin device as seen along the line 7—7 in FIG. 6.

FIG. 8 is a perspective view of a cutting apparatus incorporating another embodiment of the present invention.

FIG. 9 is an elevated frontal view in section showing the details of the toroidal fluid compartment of FIG. 8.

FIG. 10 is an elevated frontal view in section showing another toroidal fluid compartment of a type which may be utilized in the cutting apparatus of FIG. 8.

FIG. 11 is a perspective view of a cutting device incorporating still another embodiment of the present invention.

FIG. 12 is a perspective view of a cutting device employing a still further embodiment of the present apparatus with the cutting device partially cut away.

FIG. 13 is a fragmentary sectional view of the cutting device as seen along the lines 13—13 of FIG. 12.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 and 2 disclose a cutting device which is used to cut pattern pieces from a layup composed of sheets of fabric material laid flatwise one upon the other. The cutting device employs a numerically controlled cutting tool which is translated over the layup in accordance with commands derived through a computer from a punched tape or other memory device. The apparatus for holding the sheet material in a fixed position during the cutting operation includes a table which defines a work surface for supporting the material and a pressure producing mechanism for forcing the material against the work surface of the table.

The cutting device, generally designated **10**, utilizes a cutting tool in the form of a reciprocating knife **12** which is translated over the layup **14** of sheet material by two numerically controlled carriages **16** and **18**. The carriage **16** straddles the layup and includes a longitudinal motor drive (not shown) and two motor driven pinion gears (not shown) which respectively engage two parallel racks **20** and **22** at opposite lateral sides of the layup **14**. To translate the knife **12** back and forth over the layup **14** in the longitudinal direction, identified as the X direction on the layup, commands from a remotely located computer are transmitted through the control cable **24** to the longitudinal drive motor and the motor drives the pinions engaging the racks **20** and **22** in accordance with the computer commands.

The carriage **18** supports the knife **12** and is mounted on the carriage **16** for translation with respect to the carriage **16** in the lateral direction identified as the Y direction on the layup **14.** The carriage **18** is supported on the carriage **16** by rollers (not shown) which ride on a transverse guide **26** and a transverse frame member **28.** A transverse lead screw **30** mounted to the carriage **16** threadably engages the carriage **18** so that rotation of the screw **30** causes the carriage **18** and knife **12** suspended from the carriage **18** to be translated back and forth on the carriage **16** in the Y direction. The combined motions of the carriages **16** and **18** along the orthogonal X and Y directions permit the knife **12** to be translated along irregularly shaped paths through the layup **14** in response to the computer commands while cutting the pattern pieces from the layup.

A knife orienting motor **32** is mounted at the projecting end of the carriage **18** opposite the frame member **28** of the carriage **16** and rotates a platform **34** from which the knife **12** is suspended about a vertical axis normal to the upper surface of the layup so that the knife remains tangent to the cutting line at the cutting or leading edge of the knife. Another motor (not shown) on the rotating platform **34** causes the knife to reciprocate along the vertical axis to produce the cutting strokes of the knife as it moves through the layup **14.** A guide foot **36** is also suspended from the rotating platform and rotates with the knife **12.** The foot **36** is positioned against the upper face of the layup **14** during the cutting operation and prevents the upper plies of the layup from being lifted during the upward stroke of the knife. The motor **32,** platform **34,** knife **12** and foot **36** may be suspended from the carriage **18** by means of an adjustable mount to permit the knife and foot to be adjusted in the vertical direction for layups of different thicknesses.

The appratus which holds the layup of sheet material in a fixed position during the cutting process includes a table **40** on which the layup **14** is spread and a fluid compartment **42** which is mounted on the carriage **16** and receives pressurized fluid from a source such as a blower **44** on the carriage **16.** Another fluid compartment **46** is included in the embodiment of the apparatus shown in FIGS. **1** and **2** and cooperates with compartment **42** in holding the layup **14** on the table **40.**

The table **40** is supported in a horizontal position on a plurality of table legs **48** and includes an outside casing or frame **50** and a bed of material **52** defining the work surface **54** on which the sheet material is positioned flatwise, one sheet on top of the other to form the multi-ply layup **14.** The frame may be utilized as the supporting structure for the racks **20** and **22** which in turn support the carriages **16** and **18** and the knife **12.** Various materials may be used to form the bed **52,** but preferably it comprises a resilient, low-density, cellular polyethylene plastic material which may be readily penetrated by the knife **12** during the cutting operation. The reciprocating knife **12** is adjusted to partially penetrate the bed to assure accurate and efficient cutting of the lower plies in the layup **14.** Ethafoam, a product of Dow Chemical Company, has proven particularly suitable as a bed material, and such material may be supplied in blocks, as shown, to permit selected portions of the bed which receive particularly heavy usage to be replaced from time to time as required. It will be understood that other materials such as bristled mats may be used as the bed material so long as the knife can readily penetrate the material and the material provides a sufficiently rigid work surface for supporting the layup **14** in a fixed position. Of course, in operations on sheet material which do not require that a tool pass through the material, for example, a plotting operation, the necessity for a penetrable bed is not present and non-penetrable materials can be employed to define the work surface.

The fluid compartments **42** and **46** as seen in FIGS. **1** and **2** are inverted pans or shells located on opposite sides of the knife **12** and have a shape which is elongated in the Y direction. A mounting plate **60** connected to one side of the carriage **16** and a similar mounting plate (not visible) at the other side of carriage **16** have guides or keys **61, 61** and **63, 63** which mate with corresponding keyways in the confronting end walls of the compartments. The compartments **42** and **46** are adjustably suspended on the guides by means of springs or counterweights (not shown) connected to carriage **16** so that the compartments can be shifted in the vertical direction with respect to the horizontal work surface **54** to accommodate layups of different plies or thicknesses. Two flexible fluid conduits **62** and **64** are connected respectively to the fluid compartments **42** and **46** to deliver the air under pressure from blower **44** to the interior of the compartments. Each of the compartments at the side adjacent the layup **14** defines a fluid discharge opening which exposes the upper face of the layup to the pressure of the air within the compartments. Air seals in the form of flexible elastomeric skirts **66** and **68** are connected, respectively, to the peripheries of the openings of the compartments and extend downwardly toward the layup **14** and the table surface **54** to impede the leakage of the air out of the compartments and to generate a cushion of air at increased pressure under the compartments which cushion operates downwardly on the layup.

Adjustment of the biasing force of the springs or counterweights holding the compartments **42** and **46** allows the pressure of the air within the compartment to be varied so that the compartments can be lifted off of the layup on the cushion of air. The total force on the affected region of the layup under the compartment equals the combination of the weight of the compartment plus the biasing and frictional forces. As the air escapes past the skirts **66** and **68,** the stream of air assists in spreading the sheet material smoothly on the table **40** and forms a fluid bearing which permits the compartments to translate over the layup **14** on the cushion of air which supports the compartment and holds the sheet material down on the table **40.**

In operation of the cutting apparatus **10,** the layup of material is first positioned on the surface **54** of table **40** under carriage **16,** and blower **44** is started to deliver air under pressure to the compartments **42** and **46.** The pressure of the air received within the compartments is applied to regions of the upper surface of the layup on opposite sides of and immediately adjacent to the knife **12.** The air pressure forces the sheet material compactly against the work table **40** and the cutting operation is then begun. As the knife **12** traverses a cutting path through the layup, the fluid compartments **42** and **46** move with the component of the knife displacement in the X direction and the knife translates relative to and between the compartments for components of its displacement in the Y direction. In this fashion, the two

regions of increased pressure produced by the compartments move successively over adjacent portions of the layup and remain immediately adjacent the knife regardless of the position of the knife on the layup surface.

It will be understood that the pressure of the air received by compartments **42** and **46** is applied to the upper ply of the layup **14** and the force holding the layup in a fixed position on the table **40** results from the pressure differential across the plies of the layup. In cases where the layup is formed of a fabric material which is air-pervious, the pressure differential across the individual plies at the upper portions of the layup **14** may be greatly reduced due to the filtering of the air through the pervious material. Such reduced pressure differentials may not be adequate to hold the upper plies of the fabric material fixedly in position during the cutting process and accordingly, it may be desirable to provide an air-impervious covering over the layup. In such case, the upper ply of the layup, as seen for example in FIG. **2**, would be an air-impervious covering. With an impervious covering, the force resulting from the pressure differential between the top and bottom plies of layup **14** is applied across all of the plies of the layup. Such an impervious covering may be easily provided by a sheet of thin, flexible plastic film, such as a polyethylene sheet. Although the knife **12** will cut through the polyethylene in the same fashion that it cuts the fabric material, such polyethylene sheets are relatively inexpensive and may be considered expendable.

The fragmentary views of FIGS. **3**, **4** and **5** disclose an alternate construction of the sealing device which may be used on the fluid compartments **42** and **46** in FIGS. **1** and **2** in place of the flexible, elastomeric skirts **66** and **68.** In the alternate construction, the sealing device is formed by a porous or apertured member which is located at the periphery of the opening in the fluid compartment confronting the layup **14.** In FIG. **3**, a corner of a fluid compartment similar to the compartment **42** is shown with a lateral side wall **70** overhanging the edge of the layup **14** as would be the case where the layup had a Y dimension slightly less than the Y dimension of the compartment **42.** A porous or apertured member **72** is connected to the inner surface of the lateral side wall **70** at the peripheral edge of the compartment opening confronting the layup **14.** As seen in FIG. **5**, the porous member **72** has an L-shaped cross-section and is provided with a series of apertures **74, 74** extending through the portion of the member positioned parallel to the upper surface of the layup **14.** The member **72** serves as an inwardly extending seal to prevent air from escaping under the overhanging wall **70** of the compartment and the apertures **74, 74** act as pressure-staging orifices which create a staged pressure drop at the edge of the layup. If the wall **70** does not overhang the edge of a layup, the apertures **74, 74** allow air within the compartment to be admitted to the region within the member **72** and consequently the pressurized region under the compartment extends substantially to the wall **70** of the compartment without substantial differences in pressure.

Another apertured member **76** is connected to the exterior surface of the compartment wall **78** joined perpendicularly to the overhanging wall **70.** The member **76** has an L-shaped configuration and contains pressure-staging orifices or apertures **80** in the portion of the member extending parallel to the upper surface of the layup. The member **76** terminates at a point adjacent the inwardly facing edge of member **72** and is closed at this point by end wall **82.** The wall **78** to which the member **76** is attached is slightly foreshortened at the bottom edge **84** adjacent the layup **14** as best seen in FIG. **4.** When the compartment is filled with air under pressure, the foreshortened edge **84** allows air to pass readily under wall **78** and member **76** with orifices **80** serves as a pressure-staging seal to drop the pressure within the chamber gradually at the periphery of the region of layup **14** experiencing the air pressure. The apertures **80** also direct the escaping air vertically away from the layup and thereby reduce the flow of air horizontally under the lower edge **86** of member **76,** which flow lifts or shifts the upper plies of the layup, particularly where the layup has been cut by the knife **12.** The member **76,** therefore, helps keep the upper plies in a fixed position during cutting operations.

FIGS. **6** and **7** disclose another embodiment of the apparatus for holding sheet material in a fixed position while the cutting operation is performed with the cutting device **10.** In this embodiment of the invention, the holding apparatus includes the table **40** which has the same construction as that shown in FIGS. **1** and **2** and a single shell-type fluid compartment **90** which is mounted to the carriage **16** by means of two guide posts **92** and **94** which are fastened to carriage **16** at the respective ends of the carriage. The compartment **90** can shift vertically on the posts **92** and **94** for vertical adjustment relative to the horizontal table similar to the keyway-mounted compartments **42** and **46** of FIGS. **1** and **2.** The compartment **90** envelopes the knife **12,** carriage **18,** the portion of the carriage **16** along which the carriage **18** translates and is large enough to envelope the knife and carriage at each point along the portion traversed by the carriage **18** so that the compartment can be held stationary on carriage **16** while the knife is translated in the Y direction. Movements of the knife in the X direction caused by movement of carriage **16** are accompanied by corresponding movement of the compartment **90** since the mounting of the compartment over the guide posts **92** and **94** and member **28** prevents movement of the compartment relative to the carriage **16** in the X direction. The bottom side of the compartment **90** or the side confronting layup **14** is open and a flexible elastomeric skirt **100** circumscribes the opening on all sides similar to the skirts **66** and **68** in FIGS. **1** and **2.** A blower **96** is supported from the roof or top of compartment **90** at the end adjacent rack **22.** The blower **96** has a discharging conduit **98** connected to the compartment **90** for discharging air at low pressure into the compartment. Since the blower **96** is mounted directly to the compartment, the conduit **98** can be a rigid rather than a flexible conduit.

With the layup **14** positioned on the table **40** under the cutting device **10,** the blower **96** is started and air pressure within the compartment generates a cushion of air under the compartment which raises the compartment slightly off of the layup. Biasing springs on posts **92** and **94** may be used to adjust the pressure which lifts the compartments off the layup. Leakage of the air along the interfaces of compartment **90** and the carriage **16** and posts **92** and **94** can be minimized by providing sliding joints or bellows-type connections which maintain a sealed environment within the com-

partment in spite of relative movements in the vertical direction between the compartment and the carriage and posts. The cushion of air supporting the compartment **90** serves as a fluid bearing permitting the compartment to be translated over the layup in the X direction with the carriage **16** and knife **12.** Since the compartment **90** envelopes all of the portion of carriage **16** along which the carriage **18** translates, displacements of the knife **12** in the Y direction are accommodated without moving the compartment.

Although the operation of the compartment **90** is basically the same as that of compartments **42** and **46** of FIG. **1,** it will be understood that the region of the layup **14** to which the air pressure is applied completely circumscribes the knife **12** and includes that portion of the layup which is in direct contact with the knife **12.**

FIGS. **8** and **9** disclose another embodiment of the apparatus for holding sheet material which may be utilized by the cutting device **10.** The apparatus includes a table defining a work surface on which the material is supported and a pressure generating mechanism which circumscribes the cutting tool and translates with the tool over the work surface in each of the two orthogonal X and Y directions. The table **40** has the same construction as that found in the embodiments of FIGS. **1** and **6,** including a bed **52** of penetrable material. However, in addition, penetrable boundary blocks **110** and **112** are positioned on the work surface **54** contiguously with the opposite lateral sides of the layup **14.** The blocks **110** and **112** have a height above the surface **54** which is substantially equal to the height or thickness of the layup **14** as seen in FIG. **9** and are formed from the same or similar material as the penetrable bed material **52** so that the cutting tool or knife **12** can be translated beyond the edge of the layup into the boundary blocks without damaging the knife. The mechanism which generates the fluid pressure against the layup is composed of a stationary source **114** of fluid pressure, a fluid compartment **116** having a generally toroidal shell configuration and a flexible fluid conduit **118** connecting the stationary source **114** to the compartment **116.** The source **114** may be a large volume air tank or tanks but is preferably a continuous output blower which is mounted in a stationary fashion to an overhead beam or to an other permanent fixture adjacent the table **40.** The source **114** delivers air or other fluid under pressure to the compartment **116** through the flexible conduit **118** which can follow movements of the knife **12** over the entire work surface **54** of table **40.** The toroidal compartment **116** circumscribes the knife **12** and is suspended from the carriage **18** by means of two bracket plates **120** mounted to opposite lateral sides of carriage **18** so that the compartment moves with the knife **12** in both the X and Y directions. The compartment **116** may be mounted directly to the platform **34** which supports the knife **12** and foot **36** so that the compartment can be adjusted vertically above the work surface **54** in conjunction with the adjustment of the knife and foot for layups of different thicknesses. Relative movement between the stationary source **114** and movable compartment **116** may be readily accommodated by the flexible conduit **118** which may be, for example, a wire-reinforced plastic hose or similar flexible duct.

FIG. **9** shows a detailed construction of the toroidal compartment **116** in which the side of the compartment confronting the layup **14** defines an annular opening that produces an annular region of increased pressure circumscribing the knife **12.** A flexible skirt **122** is mounted to the lower edge of compartment **116** along the inner periphery of the annular opening and another flexible skirt **124** is mounted to the lower portion of chamber **16** along the outer periphery of the annular opening. Both of the flexible skirts **122** and **124** extend downwardly toward the layup **14** and the work surface **54** and may be constructed of an elastomeric material similar to the skirts **66** and **68** in FIG. **2** so that leakage of the pressurized air delivered to the compartment is minimized and a cushion of air is generated on which the compartment can ride during translation over the layup with the knife. The toroidal compartment **116** is shown in FIG. **9** at a position overlying portions of both the block **110** and the layup **14** at a lateral edge of the layup. The construction of the chamber **116** with the flexible skirt **122** and **124** requires that the blocks **110** and **112** be provided at the edges of the layup with substantially the same height as the layup and in contiguous relationship with the layup so that the knife can work in regions adjacent the edges of the layup without losing the cushion of air on which the compartment translates and without catching the compartment **116** or seal **124** on the blocks as the compartment moves over the blocks. Of course, a set of blocks having graduated heights might be provided for layups of different thicknesses.

FIG. **10** discloses another fluid compartment **130** having a toroidal shell configuration which may be utilized by the cutting apparatus **10** by connecting the compartment **130** directly to the carriage **18** in the same manner that the compartment **116** is connected in FIG. **8.** A flexible conduit **132** is connected to the compartment **130** for supplying air under pressure to the compartment **130** from either a stationary source, such as source **114** in FIG. **8,** or a translating source, such as the blower **44** in FIG. **1** or the blower **96** in FIG. **6.** The side of the compartment **130** confronting the layup **14** is a porous or perforated annulus **134** having a plurality of fine, closely spaced fluid discharge openings or channels **136, 136** forming orifices through which the air passes to generate a pressure on an annular region circumscribing the cutting tool. The annulus may be formed as an apertured plate or may be formed from a sintered material which allows air to seep through the annulus at a limited rate. The porous annulus eliminates the need for the blocks of penetrable material along the edges of the layup **14** since the inherent orificing effect of the channels **136, 136** limits the leakage of air out of the compartment **130** when the compartment overhangs the edge of the layup **14** as shown in FIG. **10.** The operation of the annulus is similar to that of the porous member **72** in FIGS. **3** and **5** except that the compartment **130** can overhang the edge of the layup by any amount without losing the cushion of air under the portion of the compartment over the layup since the annulus extends completely over the bottom side of the toroidal compartment. Even though a small quantity of air may leak through the overhanging portion of the compartment, the orificing effect maintains a pressure within the compartment sufficient to force the region of layup **14** adjacent the annulus against the work surface **54.** Of course, there is no danger of damaging the cutting tool if it should exit from the layup during the cutting process since there are no obstacles which could be hit by the tool at the edge of the layup.

FIG. 11 discloses still another embodiment of the apparatus for holding sheet material under the cutting device 10 which apparatus includes a table defining a work surface and a pressure generating mechanism which moves with the cutting tool along the X and Y directions. The table 40 which defines the work surface 54 includes the penetrable bed 52 in the same fashion as that shown in FIG. 1. The pressure generating mechanism includes a stationary source 140 of fluid under pressure, a fluid compartment 142 in the shape of a cylindrical shell mounted to the carriage 18 and enveloping the cutting knife 12 and a flexible hose 144 serving as the fluid conduit for delivering air under pressure from the source 140 to the compartment 142. The fluid compartment 142 is mounted to the carraige 18 for adjustment in a vertical direction normal to the surface 54 and is provided with seals (not shown) at the interfaces with the carriage 18 to maintain a pressurized environment within the compartment in spite of the vertical adjustment relative to carriage 18. At the lower portion of the compartment 142 confronting the layup 14, a porous annulus 146 is secured to the internal surface of the compartment and circumscribes the cutting knife 12 and foot 36. Since the compartment 142 is mounted to the carriage 18, the compartment moves with the knife 12 in both the X and the Y directions and generates a circular region of increased pressure centered on the knife at the upper face of layup 14. The annulus 146 may have a construction identical to the annulus 134 in FIG. 10 and operates in essentially the same manner as annulus 134 when the cutting tool 12 overruns the edge of layup 14. To prevent an undue loss of air if the knife 12 translates beyond the edge of th layup, it is advantageous to provide a seal between the foot 36 and the inner circular edge of annulus 146. It is also possible that the compartment 142 could have an open face confronting the layup and a flexible elastomeric skirt such as skirt 124 in FIG. 10 at the lower periphery of compartment 142 in place of annulus 146. Of course, with the skirt, it is desirable to employ boundary blocks similar to blocks 110 and 112 in FIGS. 8 and 9 to allow the knife and compartment to operate in regions near the edges of the layup.

FIGS. 12 and 13 disclose still another embodiment of the apparatus specially adapted for holding sheets of air-pervious material against a work surface while the cutting device 10 is operated. The cutting device 10 has the same construction as that shown in FIG. 1; however, the portion of the carriage 16 suspended over the table 40 and the carriage 18 which supports the knife 12 have been cut away for the sake of clarity. The construction of the apparatus for producing the region of increased pressure in the vicinity of the knife 12 is similar to the apparatus shown in FIGS. 1 and 2 in that two fluid compartments 150 and 152 in the form of inverted shells or pans are mounted for vertical adjustment with respect to surface 54 on their respective vertical guides 174 and 176 fixed to support plates 154 and 156 which are connected in turn directly to the carriage 16 at the opposite lateral sides of the table 40. A blower 158 is carried by the carriage 16 and delivers air to the compartments 150 and 152 through the flexible conduits 160 and 162. In addition to this structure, however, an endless belt 164 of an air-impervious material is mounted on two rollers 166 and 168 at opposite end faces of the chamber 150. The belt 164 circumscribes the chamber 150 and has one portion of the belt interposed between the compartment 150 and the layup 14. The rollers 166 and 168 are mounted in vertical slots 170 at each end and, therefore, are allowed to float in the vertical direction in the same manner as the compartment 150 which slides on the vertical guides 174. In the same fashion, the compartment 152 is circumscribed by an endless belt 18 of air-impervious material which is carried by two rollers 182 and 184 at opposite end faces of the compartment 152. The rollers 182 and 184 are also mounted in slots 186 in the mounting plates 154 and 156 to permit the rollers to float vertically with the compartment 152 on guides 176. Since the rollers 166, 168, 182 and 184 and the compartments 150 and 152 are all mounted to the support plates 154 and 156, the endless belts 164 and 180 are translated with the compartments and the knife 12 in the X direction by the carriage 17.

The fluid compartments 150 and 152 have open sides adjacent the layup 14 so that air delivered to the compartments 150 and 152 from blower 158 generates a pressure which is applied to the layup 14 through the portions of the impervious belts interposed between the lower, open sides of the compartments and the upper face of the layup. Friction between the belts 164 and 180 and the layup 14 causes the belts to rotate as carriage 16 translates the knife 12 in the X direction. Of course, a separate drive arrangement connected to the rollers and belts and operated synchronously with the drive motors for the carriage 16 can be provided to insure that the belts do not slide over the upper plies of the layup 14 and shift the upper plies out of position during the cutting operation. The compartments 150 and 152 remain postioned within the belts 164 and 180 during the translation in the X direction and ride on the cushion of air between the compartments and the belts. The force of the air pressure on each belt is equal to the weight of the compartment plus any biasing and frictional forces and is transmitted through the belt to a region of the layup adjacent of the knife 12 as the knife performs its cutting operation. With two regions being compressed on opposite sides of the knife, the material under the knife is also held in place.

Although the apparatus in FIG. 12 which holds the material during the cutting operation operates in basically the same fashion as the apparatus in FIG. 1, that is, the fluid compartments translate with the knife 12 only in the X direction while the knife translates between the compartments and belts in the Y direction, it is apparent that a layup composed of an air-pervious material can be cut by the apparatus in FIG. 12 without expending a cover sheet of impervious material during the cuttin process. In both apparatuses, however, pressure produced by the cutting immediately above the layup is transmitted to every ply within the layup with full force and effect. Additionally, in the apparatus of FIGS. 12 and 13, air escaping from the peripheral edges of the compartments 150 and 152 is prevented from streaming over the sheet material and, therefore, cannot lift or blow the sheet material out of position. The redirection of the fluid flowing from the compartments allows the apparatus in FIG. 12 to be utilized in cases where the fluid generating the pressure on the material should not contact the material.

While the present invention has been described in a number of different embodiments, it should be understood that still further modifications and substitutions to the method and apparatus disclosed can be had with-

out departing from the spirit of the invention. The specific shapes, sizes and mounting means for the fluid compartments can be varied according to the needs of any given operation. The fluids employed to force the sheet material against the work surface may be varied to be compatible with the particular sheet materials and processes under consideration. The utility of the invention is not limited to a cutting device or process since the invention may be applied with equally satisfactory results to numerically controlled plotters, sewing machines, drafting equipment, and other devices. Accordingly, the present invention while disclosed in a number of specific embodiments has been described by way of illustration rather than limitation.

We claim:

1. Apparatus for working on sheet material comprising: means defining a sheet-material supporting surface; a tool; means for translating the tool parallel to sheet material on the supporting surface including a first carriage movable parallel to the supporting surface in a first direction and a second carriage translatable a preselected distance on a portion of the first carriage parallel to the supporting surface in a second direction orthogonal to the first direction, the tool being mounted to the second carriage; and means for applying a fluid pressure in the vicinity of the tool to the supporting surface and material spread on the surface including a fluid compartment mounted to the first carriage for movement with the first carriage and extending in the second direction parallel to the supporting surface coextensively with the preselected distance on the first carriage.

2. Apparatus as defined in claim **1** wherein said fluid compartment comprises a shell enveloping said portion of said first carriage, said tool and said second carriage at each point along said portion of said first carriage coextensive with the preselected distance in said second direction, said shell having an open face confronting said material supporting surface and material thereon whereby said tool can be translated relative second said material supporting surface and material thereon in said secon direction within said shell, and said shell and said tool within said shell can be translated in said first direction relative to said material supporting surface and material supported thereon.

3. Apparatus as defined in claim **1** wherein said fluid compartment comprises a shell extending in said second direction a distance not substantially less than the preselected distance said second carriage translates on said portion of said first carriage and said tool is mounted to said second carriage externally of said shell and adjacent said shell.

4. Apparatus as defined in claim **3** wherein said fluid compartment comprises two shells extending in said second direction a distance not substantially less than the preselected distance said second carriage tranalates on said portion of said first carriage and positioned at translates along said first direction on opposite sides of said tool.

5. Apparatus for working on sheet material comprising: a work table having a work surface on which sheet material is supported in a spread condition; a work tool; controlled drive means for translating the tool and the sheet material spread on the work table relative to one another in two orthogonal directions parallel to the work surface, the drive means including a carriage supporting the tool and translatable a preselected distance in one of the two orthogonal directions relative to the sheet material and the work table; and fluid compartment means for exposing a portion of the sheet material adjacent the tool to pressurized fluid to force the material against the work surface, the compartment means including an elongated shell extending adjacent the tool in the one orthogonal direction in which the carriage translates and being coextensive with the preselected distance traversed by the carriage.

6. Apparatus for working on sheet material as defined in claim **5** wherein: a pair of rollers having rotational axes parallel to the one orthogonal direction in which the carriage translates relative to the table extend over the work surface at opposite sides of the elongated shell, one of the rollers being placed between the tool and the adjacent elongated shell; and an endless belt having one portion interposed between the shell and the work surface of the table circumscribes the shell and is carried by the rollers.

7. Apparatus for working on sheet material comprising: a work table having a work surface on which sheet material is supported during a work operation; a tool; drive means for moving the tool and the sheet material on the work table relative to one another in two orthogonal directions parallel to the work surface of the table, the drive means including at least one carriage traversing the work table in one of the two orthogonal directions; fluid compartment means including a shell structure in the form of an inverted pan for receiving a pressurized fluid, the pan defining an opening confronting the work surface and being in close proximity to the sheet material on the work surface for exposing at least a portion of the material on the work table to the pressurized fluid received within the pan to force the material against the work surface, the pan also being suspended from the carriage traversing the table in the one orthogonal direction for movement with the tool adjacent the exposed surface of the sheet material; and sealing means circumscribe the opening in the pan to impede the leakage of pressurized fluid from the pan.

8. Apparatus as defined in claim **7** wherein the sealing means comprises a pressure-stage seal surrounding the opening.

9. Apparatus as defined in claim **7** wherein the sealing means comprises a flexible skirt attached to the shell structure.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,750,507 Dated August 7, 1973

Inventor(s) Heinz Joseph Gerber and David R. Pearl

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 9, line 34, delete "th" and substitute --the--.

Col. 10, line 17, delete "17" and substitute --16--.

Col. 10, line 54, delete "cutting" and substitute -- compartments -- .

Col. 11, line 40, delete "second" and substitute --to--.

Col. 11, line 42, delete "secon" and substitute --second--.

Col. 12, line 1, delete "translates" and substitute --stations--.

Signed and sealed this 8th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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