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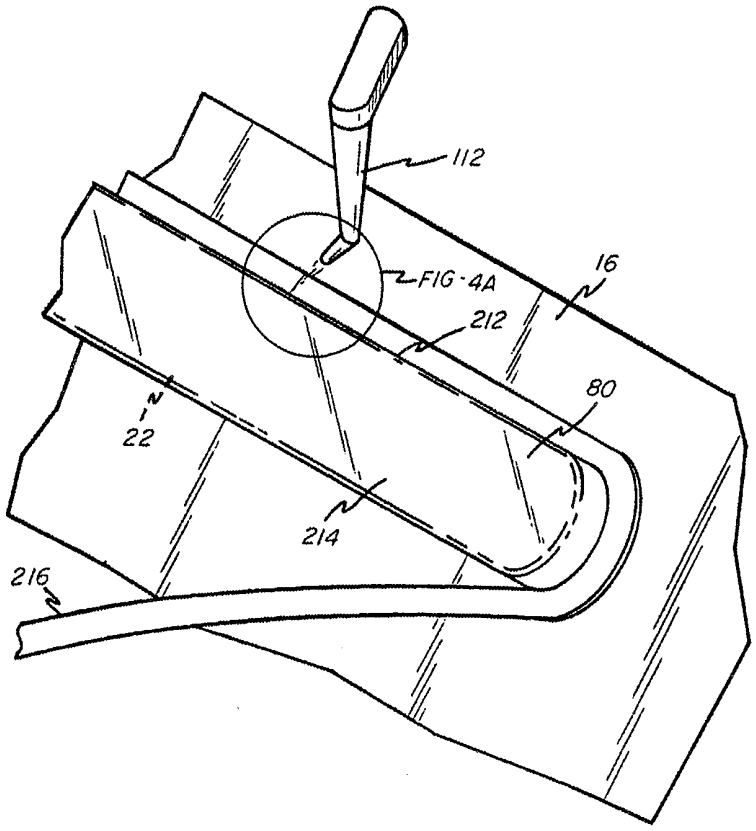
(54) Title: METHOD AND APPARATUS FOR TRIMMING SHAPED PLASTIC WORKPIECES

(57) Abstract

A method and apparatus for trimming a shaped plastic workpiece (80) use a laser beam positioned and directed by a robotic arm (114) traveling along a pre-programmed path (212) to trim the edges of a workpiece (80) held against a positioning block (22). Preferably, the positioning block (22) includes suction holes (94) for removing smoke generated by the ablation and burning of the plastic so as to minimize the risk of smoke damage to the workpiece (80) and to remove soot and vapors from the work area.



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METHOD AND APPARATUS FOR TRIMMING SHAPED PLASTIC WORKPIECES

Field of the Invention

The present invention pertains to a method and apparatus for trimming a shaped plastic workpiece such as a paint film laminate that is to be used to form an injection molded automotive or truck part. The method uses a laser beam positioned and directed by a robotic arm along a pre-programmed path to trim the edges of the paint film laminate workpiece as the workpiece is held against a positioning block.

Background of the Invention

A variety of injection molded parts are made and used for automobile body and trim parts. For example, bumpers, spoilers, body panels, doors, filler panels, wheel covers, dashboards, arm rests and other parts are commonly made by the injection molding of thermoplastic materials.

In order to provide a painted or other decorative surface for injection molded plastic trim parts, film lamination techniques are commonly employed. A paint film laminate is insert molded or, as it is sometimes referred to, co-molded, with the desired thermoplastic to fuse the film over the injection molded substrate. The resulting injection molded film-plastic part is ready for assembly without subsequent painting.

The paint film laminate used in these insert molding techniques may comprise a backing sheet to which paint, other pigment-containing, or clear layers are adhered. Typically, the backing sheet comprises an extruded thermoplastic sheet. The paint or pigment layer may contain colored pigments or reflective flake pigments such as aluminum or mica flakes to provide for example a metallic finish.

The paint film may consist of a monocoat; a clear coat over a base coat; or a clear coat and a base coat with interposed print or design. The paint film, including base coat, clear coat and print or design, if desired, may range from about 0.5-4 mil. (13-100 μm) in thickness.

Laminated paint films are well known in the art and are available, for

example, from Avery Dennison Decorative Films Div. of Schererville, Indiana, or Rexham Decorative Products of Charlotte, North Carolina. For example, laminated paint films are described in U.S. Patent 5,514,427, the disclosure of which is incorporated herein by reference. The films are typically provided in a roll, unwound and then "preformed" to a size and shape approximating that of the final injection molded film-plastic part.

The paint film laminate preform is next usually trimmed and placed along the cavity side of an injection mold with the painted side or "show" side thereof facing the mold cavity surface. Trimming may be accomplished by hand or in some instances by the use of heavy stamping machines that require the use of expensive tooling.

After trimming, the paint film laminate preform is ready for the molding process where it may be placed along the core side of the mold. The mold is then clamped and the desired molten resin is injected into the mold cavity. Heat and pressure conditions in the mold partially melt the backing sheet and a melt bonding or fusion of the injected resin and the backing sheet of the film occur. Injection molds used for these processes are rear or edge gated so that the molten resin is directed along the backside of the film.

Techniques for preforming paint film laminates and insert molding film-plastic parts are disclosed in U.S. Patents 5,599,608; 5,759,477; and 5,783,287. The disclosure of these patents is incorporated herein by reference.

While the prior art process described above has proven effective in many respects, there is a need in the art to improve upon the trimming step for the paint film laminate so that this operation can be conducted economically and more accurately. At the same time, it is desirable to minimize the use of heavy stamping or cutting machines that require large spatial areas and expensive cutting tools and dies.

It is even more desirable to provide a laser trimming operation wherein operation of the laser is conducted in an enclosed atmosphere, shielding workers from the laser beam and from soot and vapors that emanate from the cutting operation. Another desirable goal is to provide an automated laser trimming

apparatus wherein soot and vapors from the laser cutting area are immediately removed from the trimming area to a bag house or other filter mechanism.

Summary of the Invention

These and other objects are met by the paint film laminate trimming apparatus and process of the present invention. Basically, the apparatus comprises a rotatable wall carrying a work platform with the platform including a plurality of convex positioning blocks mounted thereon. Each positioning block is contoured to correspond in shape and dimension to a desired work piece such as an automobile or truck trim part.

In a first work station, the operator, which can include manual or robotic means, loads a plurality of "preformed" and roughly trimmed paint laminate films over each of the positioning blocks. The roughly trimmed paint films are dimensioned so that they snugly fit over the corresponding positioning blocks. After all of these paint films are properly positioned over their corresponding positioning blocks, the wall and associated platform are rotated to an enclosed work chamber wherein a laser performs a final, highly accurate trimming of the paint laminate films.

In the laser cutting operation, X, Y, and Z coordinates of the desired cutting pattern are contained in the memory of a microprocessor. The microprocessor then provides this information to a laser controller which in turn moves the laser along the desired cutting pattern to finally trim the paint film laminates, each of which is positioned on its associated positioning block.

The positioning blocks each include a plurality of suction ports positioned along the path of travel of the laser. These ports communicate with a manifold and plenum chamber so that a suction source in operative association with the manifold and plenum chamber draws particulates and vapors from the laser cutting area to a bag house or other effective filter mechanism. This suction action also helps to grip or secure the paint film laminate to the positioning blocks.

The laser includes a source that generates a laser beam which is used to burn or ablate the workpiece along the path of travel. The projector is in optical

communication with the laser source, preferably through a flexible or jointed optical conductor, so that the projector receives the laser beam from the laser source and projects it onto the workpiece positioned on one of the convex positioning blocks.

The robot positions and orients the projector to direct the laser beam toward the convex positioning block and workpiece mounted thereon. Most preferably, the robot includes a first arm or spar having proximal and distal ends. The spar includes a wrist portion near its proximal end on which the projector is mounted. The robot also includes a second arm or boom having a proximal end pivotally supported by a base. The boom has a distal end near which the boom pivotally supports the proximal end of the spar.

The controller electrically communicates with robot electric motors positioned near the wrist portion as well as near the proximal ends of the spar and the boom to enable the robot to move the projector so that the laser beam traces the path of travel programmed into the controller. Most preferably, the controller signals the robot electric motors to orient the projector so that the laser beam remains normal to the tangent of the path of travel and maintains a constant angle with a plane containing that path as the laser beam traces the path.

The invention will be further described in conjunction with the attached drawings and in the ensuing detailed description.

Brief Description of the Drawings

Fig. 1 is a side elevational view of a rotatable laser cutting unit according to the present invention;

Fig. 2 is a perspective view of a convex positioning block for the laser cutting unit of Fig. 1, partially cut away along the line 2-2 in Fig. 1 to show suction ports opening through the surface of the block;

Fig. 3 is a schematic view showing a laser projector for use with the laser cutting unit of Fig. 1 mounted on a robotic arm;

Fig. 4 is a schematic view of the laser projector of Fig. 3 trimming a paint film laminate workpiece;

Fig. 5 is a block diagram showing the preferred system for controlling

the movement of the laser in accordance with the invention;

Fig. 6 is a partially cut away top plan view showing the rotatable wall and work platform in the open or loading position wherein the operator may manually load pretrimmed paint film laminate parts onto the positioning blocks; and

Fig. 7 is a partially cut away top plan view showing the rotatable wall and work platform positioned in the safety enclosure ready for operation of the laser-trimming position.

Detailed Description of the Preferred Embodiment(s)

As shown in Fig. 1, a laser cutting unit 10 in accordance with the invention includes a metallic work platform 16 carrying a plurality of convex positioning blocks 22, 24, 26, 28, 30 and 32 thereon. The work platform 16 is attached to rotatable wall 40 by horizontal truss members 42, 44 with mounting brackets 52, 54 respectively formed in the trusses for fixed mounting of the bottom portion of work platform 16 therein.

The work platform 16 and wall 40 may be rotated by rotatable shaft 60 that is driven by electric motor 62. As shown in Fig. 1, the proximal ends of the trusses 42, 44, in this position, rest upon stationary legs 46, 48 that are in turn fixed to stationary base 50. Accordingly, the entire wall 40, associated work platform 16, and trusses 42, 44 are positioned for rotation between: (1) a loading and unloading station and (2) a laser trimming station, as shall be explained hereinafter.

The unit 10 includes an air manifold 20 (best shown in Fig. 2) formed by the interior housing of platform 16. The manifold communicates with chamber 70, with both the manifold and chamber being operatively connected to a vacuum source (not shown). Air, gases and soot that are present near the platform are drawn via the action of the vacuum source, through the manifold and chamber to a bag house or other air cleaning device (not shown).

Each of the convex positioning blocks 22, 24, 26, 28, 30, 32 has an outer contour complementary to the contour of the concave workpiece 80 which it is desired to trim. As shown in Fig. 2, the block 22 includes a peripheral groove 90; a series of hold down ports 92 and a series of suction ports 94 communicating with a

plenum 96, the manifold 20 and ultimately with chamber 70. Each convex positioning block 22, 24, 26, 28, 30, 32 is provided with an associated plenum 96 that in turn communicates with the manifold 20.

The hold down ports serve primarily to secure the workpiece 80 against the block 22. The suction ports 94 serve primarily to draw gases and soot evolved from the burning or ablation of the workpiece 80 into the plenum 96. The suction ports 94 preferably are larger in diameter than the hold down ports 92 so as to draw a greater volume flow of air from into the plenum 96 from the vicinity of the groove 90.

When the rotatable wall and associated work platform are rotated to the laser trimming station, the workpiece 80 is trimmed by means of a laser beam which is generated by a laser source 110 (Fig. 3) and projected against the workpiece 80 by means of a projector 112 (Fig. 3). As shown in Fig. 3, the projector 112 is mounted on a robot 114. The robot 114 is programmed to move the projector 112 so that the laser beam projected by the projector 112 traces a path of travel near the periphery of the workpiece 80.

The preferred laser source 110 is a 200 W laser available from Synrad, Inc. of Mukilteo, Washington. Preferably, the source 110 itself remains stationary on a shelf (not shown) positioned above the laser cutting unit 10 (Fig. 2). The laser beam generated by the source 110 is transmitted to an optical conduit 120 which, in turn, conducts the beam to the projector 112. The optical conductor 120 includes a series of pivotally coupled sections 122, 124 and 126 which allow the robot 114 to translate and re-orient the projector 112 so as to direct the laser beam onto the workpiece 80 (Fig. 2).

The preferred robot 114 is available from FANUC Robotics Corp. of Auburn, Michigan. It includes a spar or first robotic arm (shown in phantom at 130) having a proximal end 132 and a distal end 134. A wrist portion 136 near the distal end 134 of the spar 130 supports the projector 112 for pivotal movement around a first pivot axis 138 and a second pivot axis 140. The robot 114 also includes a boom or second robotic arm 150 (shown in phantom) having a proximal end 152 and a distal end 154. The boom 150 supports the proximal end 132 of the spar 130 near its

distal end 154 for pivotal movement around a third pivot axis 156. In addition, the robot 114 includes a base 160 (shown in phantom) which supports the proximal end 152 of the boom 150 for pivotal movement around a fourth pivot axis 162 and a fifth pivot axis 164, which intersect at a pivot point 166.

The wrist portion 136 includes a pair of blocks 170 and 172; a link 174; a first robot electric motor 176; a yoke 178 affixed to the spar 130 and a second electric motor (shown schematically at 180). The projector 112 is directly supported by the block 170. The blocks 170, 172 are connected by the link 174 eccentrically to the first pivot axis 138. The block 172 is mounted on a drive shaft (not shown) of the first robot electric motor 176 so as to cause the first robot electric motor 176 to pivot the projector 112; the blocks 170, 172; and the link 174 as a unit relative to the first pivot axis 138. The projector 112 itself includes an elbow 190 to direct the laser beam at an angle transverse (preferably perpendicular) to the first pivot axis 138.

The first robot electric motor 176 itself is supported by the yoke 178. The second robot electric motor 180 is housed within the yoke 178 so as to enable the second robot electric motor 180 to pivot the first electric motor 176 (and the direction of the first pivot axis 138) relative to the second pivot axis 140.

A third robot electric motor (shown schematically at 200) is housed within the distal end 154 of the boom 150 to cause the spar 130 to pivot relative to the third pivot axis 156. Fourth and fifth robot electric motors (shown schematically at 202 and 204) are housed within the base 160 to cause the boom 150 to pivot relative to the fourth and fifth pivot axes 162, 164, that is, relative to the pivot pint 166.

A controller 210, which is preferably a microprocessor, is in electrical communication through means well known to those of ordinary skill in the art with the robot electric motors 176, 180, 200, 202, 204 so as to induce the robot electric motors 176, 180, 200, 202, 204 to move the projector 112 so that the laser beam traces a path of travel (212 in Fig. 4) programmed into the controller 210.

Referring next to Fig. 4, a preferred method for trimming a plastic workpiece 80 begins by mounting the workpiece 80 on one or more of the convex positioning blocks (only block 22 shown in Fig. 4) so the path 212 along which the

workpiece 80 is to be trimmed lies adjacent the peripheral groove 90. At least a partial vacuum is drawn through the plenum 96 (Fig. 2) and the hold down ports 92 (Fig. 2) of the block 22 to secure the workpiece 80 to the block 22. Next, the path of travel 212 is programmed into the controller 230 (Fig. 3). The controller 230 induces the robot electric motors 176, 180, 200, 202, 204 to move the projector so that the laser beam traces the path of travel 212 to separate a first portion 214 of the workpiece 80 from a second (scrap) portion 216. Preferably, the laser beam is directed normally to a tangent of the path of travel 212 and at a constant angle with the plane of the work platform 16. As the laser beam burns or ablates the workpiece 80, gases and soot generated by the process are removed through the suction ports 94 (Fig. 2). When the first and second portions 214, 216 of the workpiece 80 have been completely separated, the vacuum drawn through the plenum 96 is released so that the first portion 214 of the workpiece 80 can be removed.

Fig. 5 provides a simplified block diagram showing the manner in which the laser is ultimately driven along the desired path to perform its accurate cutting operation on the plurality of paint film laminate workpieces each of which is positioned on its associated convex positioning block.

In accordance with conventional techniques, X, Y, and Z cutting coordinates for the desired cut or trim are provided as input and are digitized. This information is fed as memory to a microprocessor unit that, in turn, provides this information to controller 210 that in turn provides drive input for motors 176, 180, 200, 202, 204 (see Fig. 3).

The manner in which the laser drive is controlled is not an essential part of the invention and, accordingly, the provision of coordinates for the desired cutting pattern and correlated laser drive can be provided by a variety of conventional techniques. Examples of suitable laser control methods are detailed for example in U.S. Patents 5,698,121 (Kosaka et al.); 4,918,611 (Shyu et al.) and 5,466,909 (Nihei et al). The disclosures of these patents are incorporated by reference herein.

Figs. 6 and 7 illustrate a preferred embodiment of the invention in which the wall 14, associated platform 16 and support trusses 42, 44 can be rotated between: (1) a loading and unloading station and (2) the laser trimming station with

operation at the laser trimming station proceeding as set forth above. With reference first to Fig. 6, the wall 14 and associated platform 16 are positioned at the loading and unloading station 526. As shown, the assembly is housed by said wall members 502, 504 and end wall member 506, the latter of which defines the end-wise boundary for the laser trimming station 524. The housing is open ended at the loading and unloading zone 526. Roof 510 extends over the assembly from the middle of the side walls to the end wall 506. Accordingly, a closed chamber is provided in the laser trimming station 524. In Figs. 6 and 7, the roof member 510 is partially broken away. This is necessary to reveal the positioning of the wall and platform in the laser trimming station 524 shown in Figs. 7 and 8.

In accordance with the inventive methods, the wall 14, platform 16 and associated trusses 42, 44 are first caused to rotate so that the platform 16 is presented in the position shown in Fig. 6. Here, an operator places the preformed and roughly trimmed paint film laminate workpieces over the corresponding convex positioning blocks that are mounted on the work platform. Then, the platform 16 and its associated support mechanisms including the wall 14 and trusses 42, 44 are rotated so that the platform 16 is positioned in the laser trimming station 524 with, as aforementioned, the laser trimming station being enclosed by wall members 502, 504, 506 and roof 510.

While in the enclosed chamber, the laser cutting of the paint film laminate workpieces is performed. As aforementioned, gases and particulates are drawn through the positioning blocks through manifold 20 and chamber 70 to a bag house or other air cleaning station. Accordingly, the entire laser cutting operation is performed in an enclosure so as to shield the work force from the laser beam and the gases and particulates that are formed as an undesirable byproducts of the cutting operation.

After the laser cutting operation is performed, the platform 16 and its associated support mechanisms are rotated back to the position shown in Fig. 6. The operator then unloads the accurately dimensioned laser cut workpieces from the platform, and provides preformed roughly trimmed workpieces over the positioning blocks so that the precise laser trimming cycle can be again commenced.

While this invention has been described with respect to particular embodiments thereof, it is apparent that numerous other forms and modifications of this invention will be obvious to those skilled in the art. The appended claims and this invention generally should be construed to cover all such obvious forms and modifications which are within the true spirit and scope of the present invention.

CLAIMS

1. A method of trimming a paint film laminate workpiece to correspond to predetermined dimensions comprising:

a) placing said paint film laminate on a work platform;

b) trimming said laminate to said predetermined dimensions; and

c) venting volatiles and particulates that may be formed by said trimming away from said work platform.

2. A method as recited in claim 1 further comprising providing a port proximate said work platform, and wherein said venting comprises applying a source of suction through said port to thereby vent said vapors and particulates.

3. A method as recited in claim 2 wherein said trimming comprises cutting said laminate with a laser.

4. A method as recited in claim 3 wherein said work platform comprises a convex shaped positioning block, said block having said port mounted therein.

5. A method of trim cutting a thin film laminate work piece comprising:

a) placing said thin film laminate on a work platform;

b) moving said platform to an enclosed housing; and

c) laser trimming said laminate to predetermined dimensions while in said enclosed housing.

6. Method as recited in claim 5 further comprising d) venting volatiles and particulates from said laser trimming step.

7. Method as recited in claim 6 further comprising venting said volatiles and particulates through a suction channel.

8. Method as recited in claim 7 further comprising moving said platform after said laser trimming step c) to an unloading station.

9. Method as recited in claim 8 further comprising placing apertures in said platform in communication with said suction channel.

10. Method as recited in claim 9 further comprising providing a convex positioning block on said work platform, said apertures provided in said positioning block and wherein said placing a) comprises placing said thin film laminate on said positioning block.

11. A method for trimming a workpiece defining a concave workpiece contour, said method comprising the steps of:

a) positioning said workpiece on a convex positioning block having a block contour complementary to said workpiece contour;

b) projecting a laser beam onto a surface of said workpiece to trim said workpiece;

c) providing suction ports in said convex positioning block; and

d) drawing at least a partial vacuum through suction ports to vent particulates and volatiles away from said workpiece.

12. A method for trimming a workpiece defining a concave workpiece contour having a re-entrant section, said method comprising the steps of:

a) positioning said workpiece on a convex positioning block, said positioning block having a groove;

b) programming a controller to define a path of travel lying proximate said groove;

c) positioning a projector to direct a laser beam onto said workpiece at said home position on said path of travel;

d) moving said projector to induce said laser beam to trace said path of travel on said workpiece; and

e) drawing at least a partial vacuum through suction ports communicating with said groove.

13. Apparatus for trimming a paint film laminate workpiece to correspond to a predetermined dimensional configuration, comprising:

a) a work platform having said workpiece mounted thereon;

b) trimming means in operative association with said work platform for cutting said laminate so that said laminate corresponds to said predetermined dimensional configuration;

c) a channel communicating with said work platform; and

d) means for drawing a draft through said channel to thereby vent particulate and volatiles that may be formed by said trimming means b) away from said work platform.

14. Apparatus as recited in claim 13 wherein said platform comprises a convex positioning block and wherein said laminate is placed on said positioning block, said block comprising at least one opening therein in communication with said channel.

15. Apparatus as recited in claim 14 wherein said trimming means b) comprises a laser cutting.

16. Apparatus as recited in claim 13 further comprising means for moving said platform to an enclosed housing and wherein said trimming means b) is located in said enclosed housing.

17. Apparatus for trimming a workpiece comprising:

a convex positioning block for positioning the workpiece thereon, said convex positioning block having a block contour complementary to a contour of said workpiece;

a projector for directing a laser beam onto the workpiece when the

workpiece is positioned on said positioning block;

a robotic arm having a distal end, said projector being supported near a distal end of said robotic arm for movement along a path of travel; and

a programmable controller for inducing said robotic arm to move said projector so that said laser beam traces said path of travel.

18. The apparatus as recited in claim 17 wherein said positioning block includes a vacuum source for drawing at least a partial vacuum and a plurality of suction ports communicating with said vacuum source, said plurality of suction ports being arranged along said path of travel.

19. The apparatus as recited in claim 17 wherein said positioning block is convex, defining a groove along said path of travel for receiving a re-entrant portion of said workpiece; and wherein said suction ports open through said groove.

20. The apparatus as recited in claim 17 wherein said positioning block includes a plurality of hold-down ports positioned within said path of travel and communicating with said vacuum source, each of said suction ports being larger than any of said hold-down ports.

21. The apparatus as recited in claim 17 including a laser light source and an optical conduit for conducting laser light between said optical source and said projector.

22. The apparatus as recited in claim 17 including a wrist portion supported near said distal end of said robotic arm for rotatably mounting said projector.

23. The apparatus as recited in claim 17 including a boom pivotably mounting said robotic arm.

24. The apparatus as recited in claim 23 including a base pivotably mounting said boom.

25. The apparatus as recited in claim 17 wherein said controller is a microprocessor electrically communicating with a plurality of electric motors for controlling movement of said robotic arm and said projector.

26. Apparatus for trimming a concave plastic workpiece comprising:

a convex positioning block having a block contour complementary to a workpiece contour;

said convex positioning block defining a plenum and a plurality of hold-down ports communicating with said plenum;

a vacuum source communicating with said plenum for drawing at least a partial vacuum through said hold-down ports;

a laser source for generating a laser beam;

a projector optically communicating with said laser source for directing said laser beam toward said convex positioning block;

a spar defining a spar proximal end and a spar distal end;

a wrist portion mounted near said spar distal end, said wrist portion including a first robot electric motor for pivoting said projector along a first pivot axis and a second electric motor for pivoting a direction of said first pivot axis;

a boom having a boom proximal end and a boom distal end, said boom pivotally supporting said spar proximal end near said boom distal end;

a third robot electric motor for pivoting said spar relative to said boom;

a base pivotally mounting said boom proximal end;

a fourth robot electric motor for pivoting said boom relative to said base;

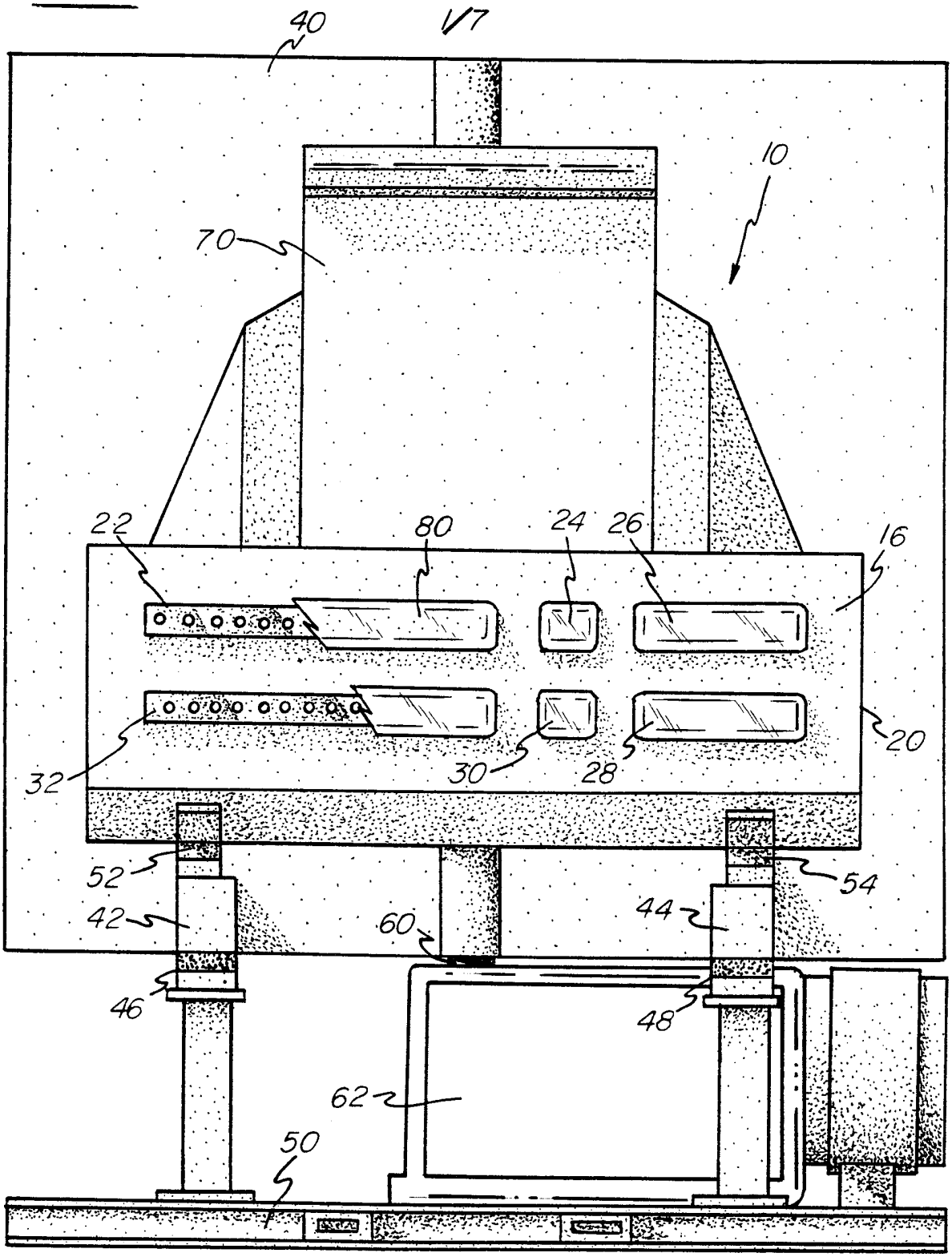
a fifth robot electric motor for pivoting said boom relative to said base; and

a controller programmed to recognize a path of travel along said

convex positioning block, said controller being in electrical communication with said first, second, third, fourth and fifth robot electric motors to induce movement of said projector so that said laser beam traces said path of travel;

said convex positioning block including a groove extending along said path of travel and a plurality of suction ports communicating between said plenum and said re-entrant groove, said suction ports being larger than said hold-down ports.

FIG -1



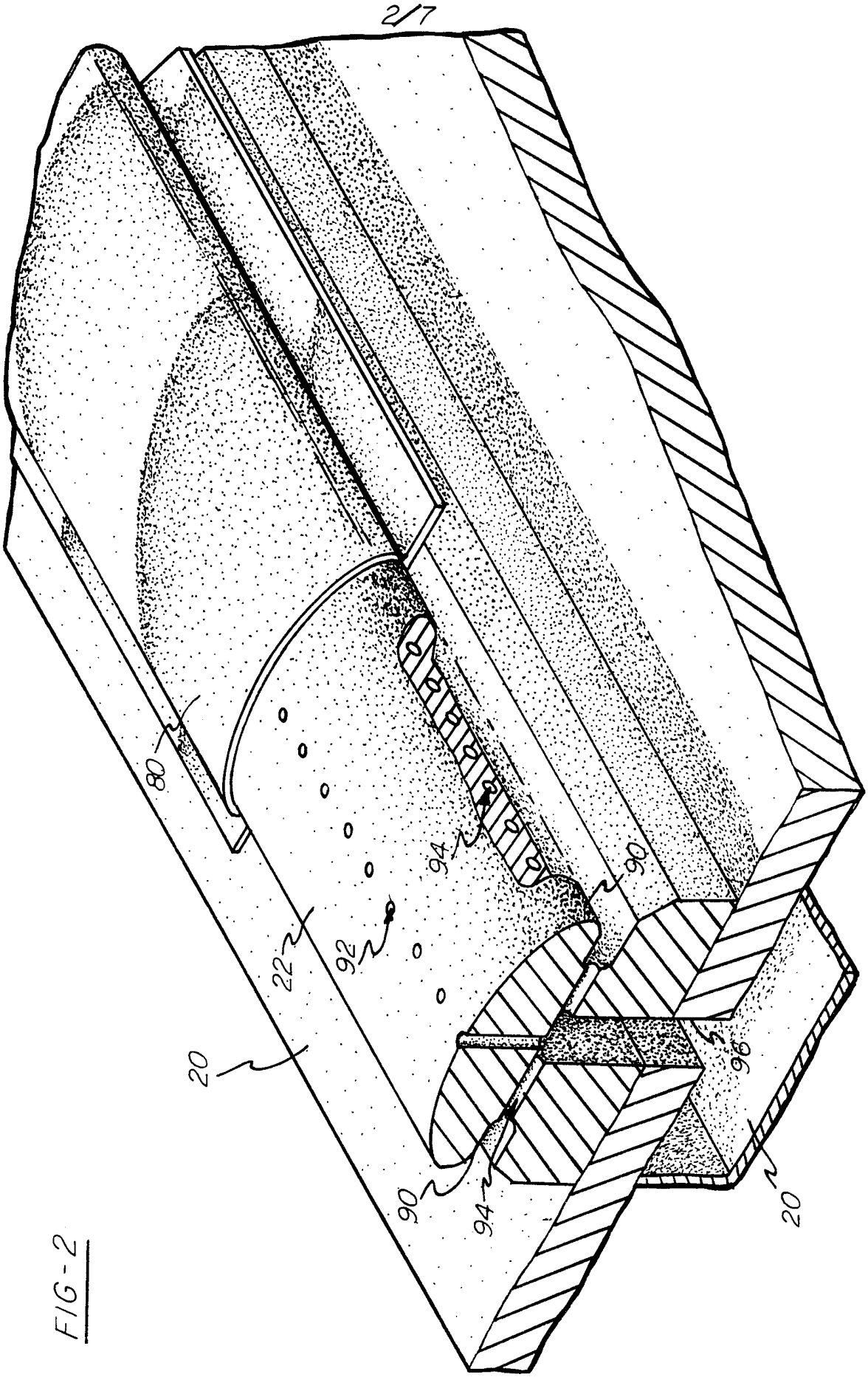


FIG-2

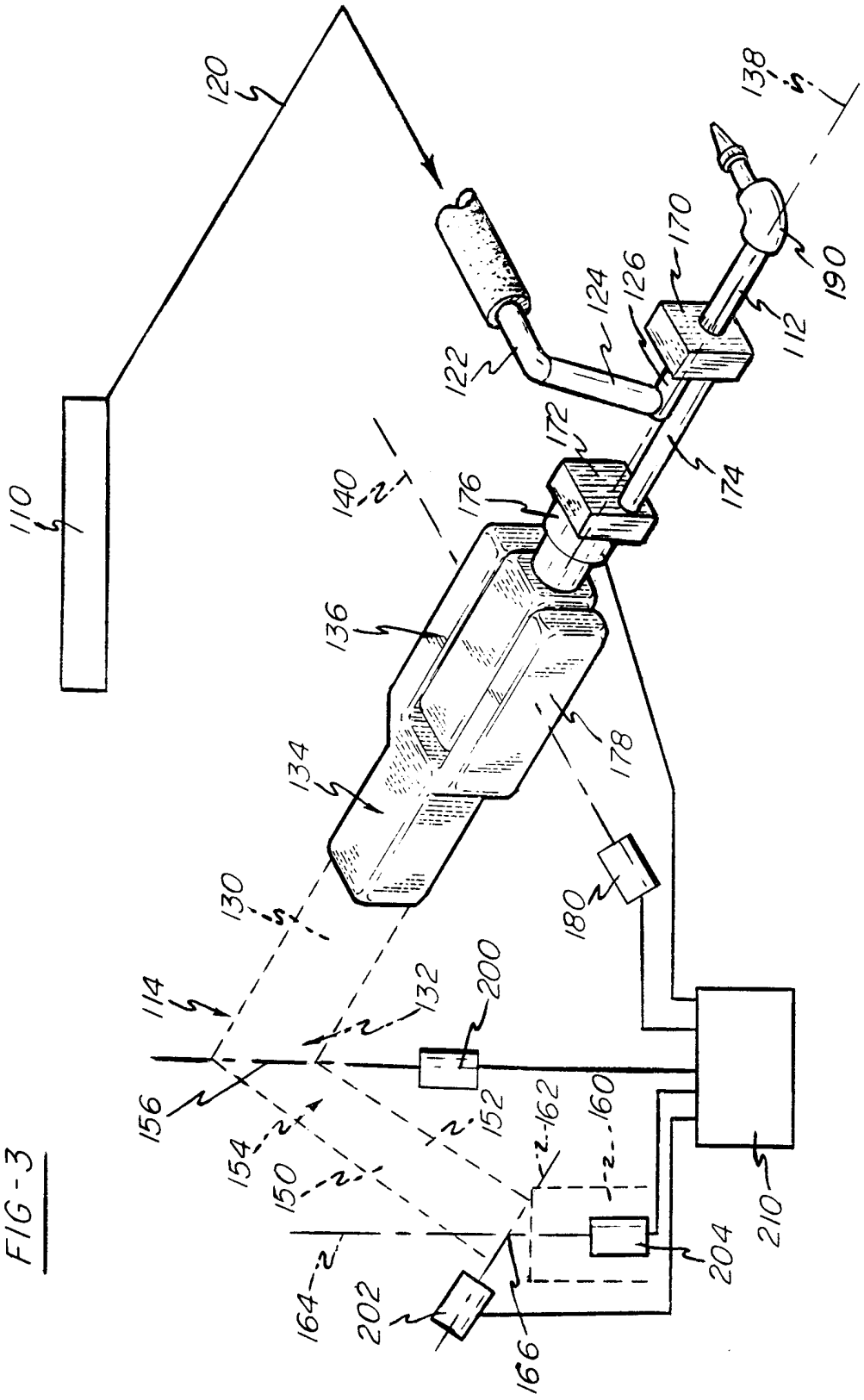

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FIG-3

FIG - 4

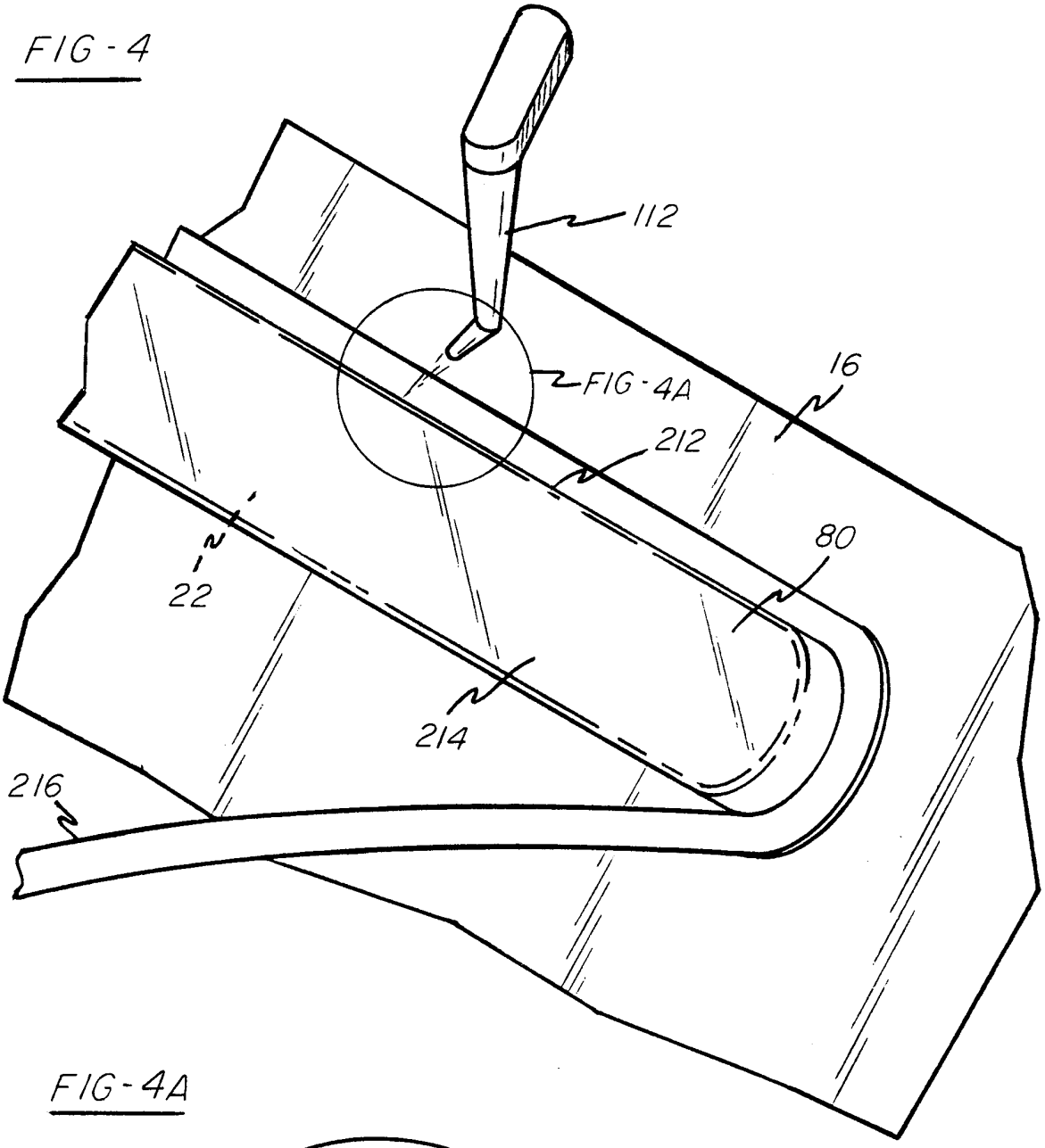


FIG - 4A

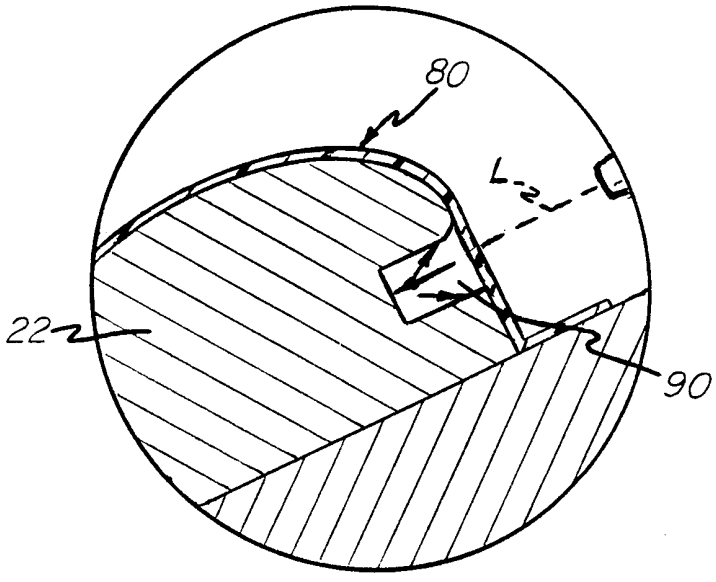
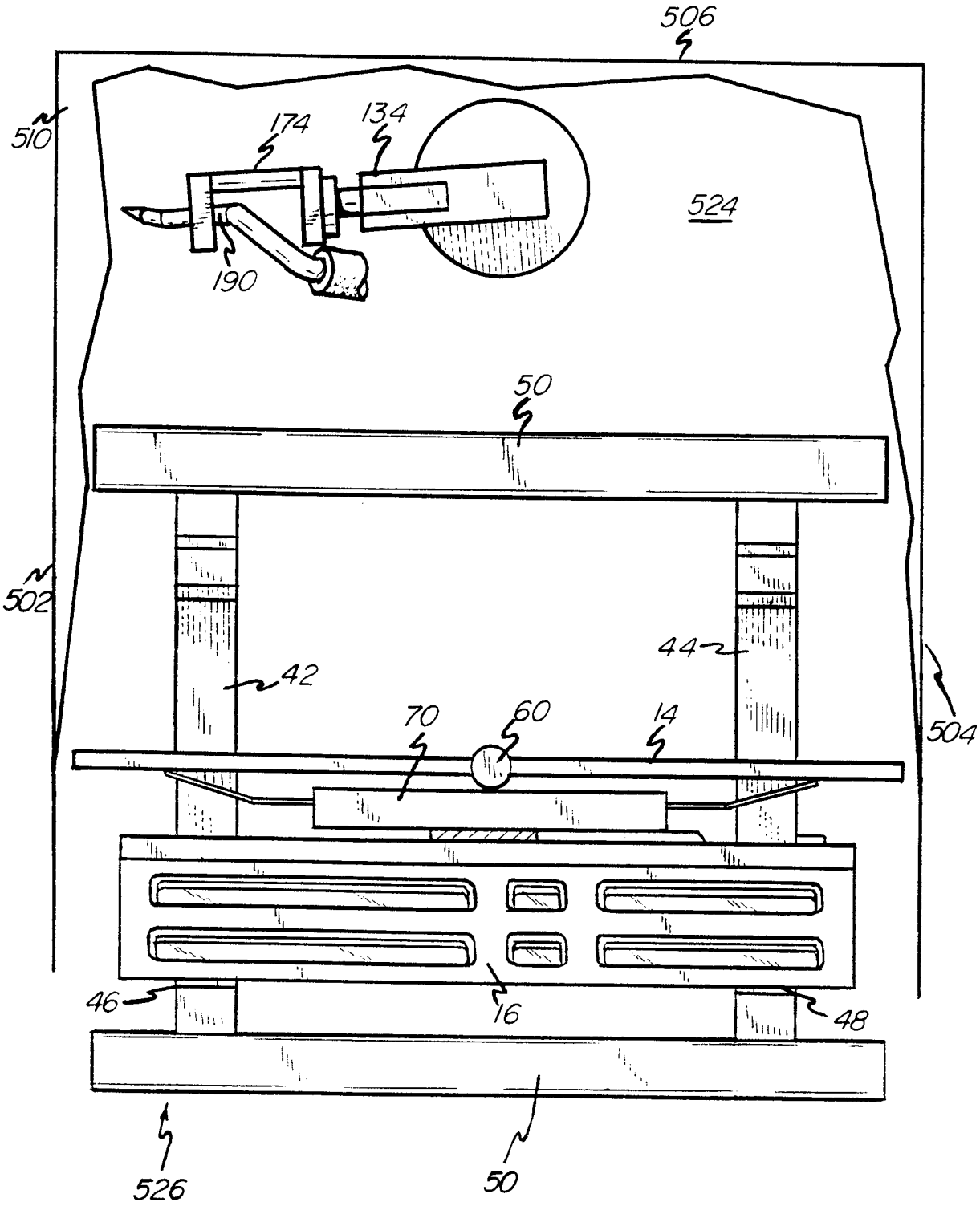


FIG - 6



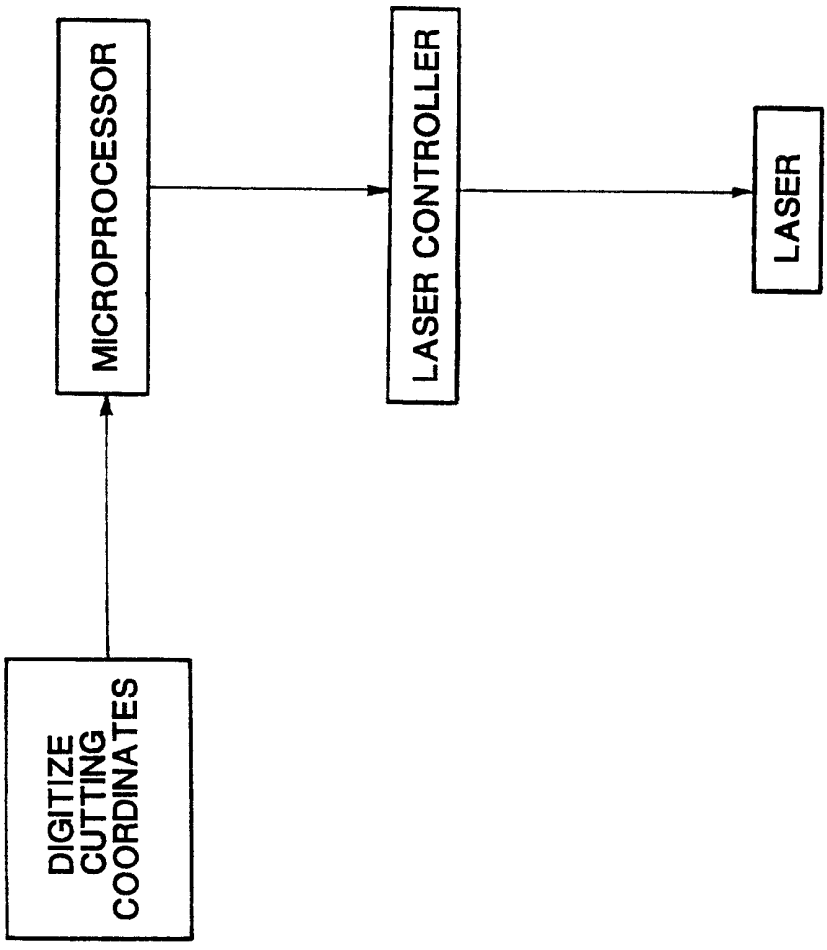
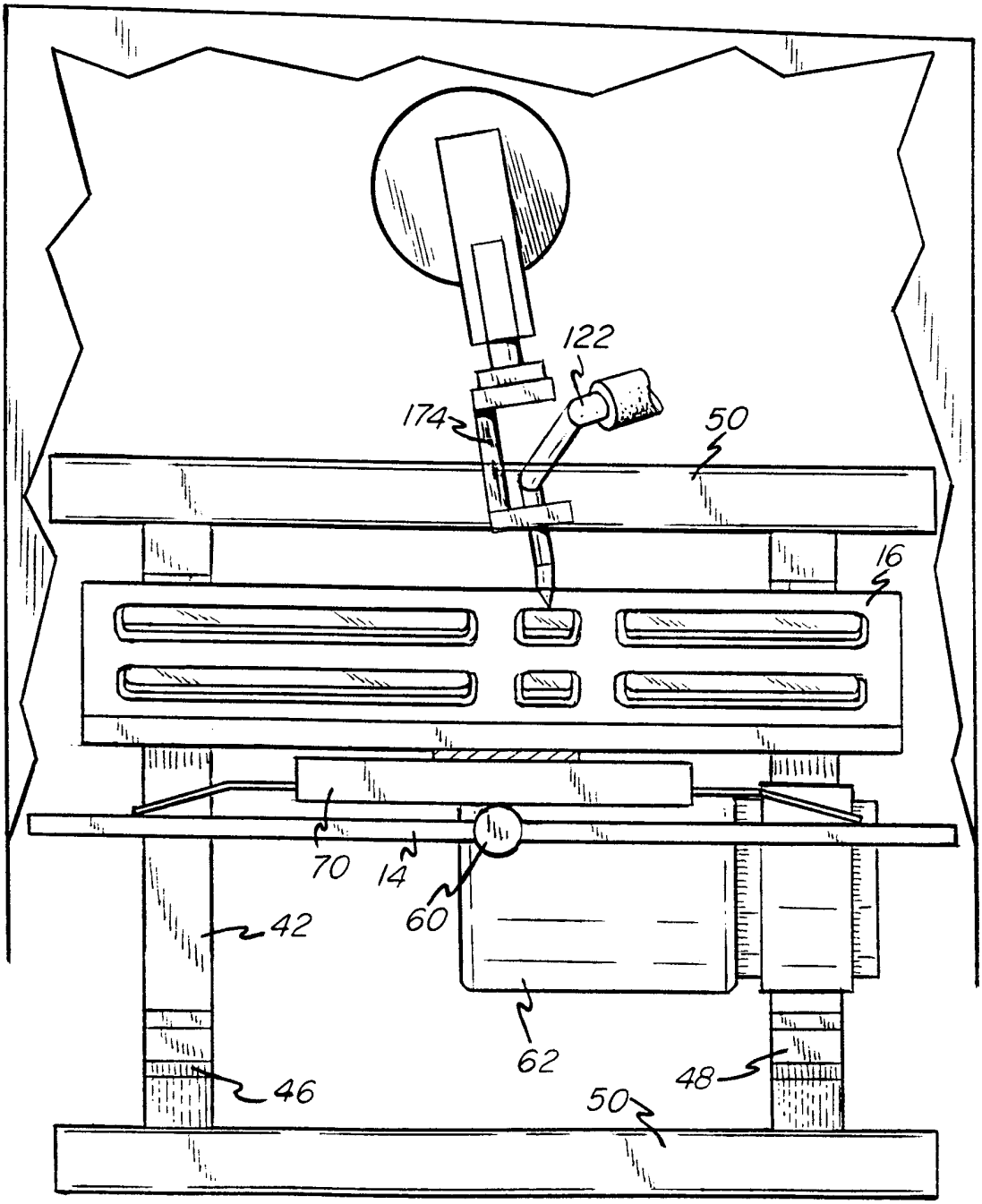

DIGITIZE CUTTING COORDINATES
MICROPROCESSOR
LASER CONTROLLER
LASER

FIG - 5

FIG-7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/01795

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B23K 26/10

US CL : 264/400, 102, 161, 162; 219/121.67, 121.68, 121.69

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 264/400; 102, 161, 162; 219/121.67, 121.68, 121.69

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,897,520 A (CARTER et al.) 30 January 1990, see col. 1, line 61 through col. 2, line 46	1-3
Y	US 4,851,061 A (SORKORAM) 25 July 1989, see entire reference	4-7, 9-15, 18-20
Y	US 5,698,121 A (KOSAKA et al.) 16 December 1997, see entire reference	8, 17, 21-26
Y	US 5,431,865 A (QUIN) 11 July 1995, see entire reference	1-2
A	US 5,038,015 A (EINAV et al.) 06 August 1991, see entire reference	21-26
A	US 5,187,967 A (SINGH et al.) 23 February 1993, see entire reference	1, 4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 APRIL 2000	10 MAY 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer STEFAN STAICOVICI Telephone No. (703) 308-0651

Form PCT/ISA/210 (second sheet) (July 1998)★