Oct. 9, 1962 L. J. VANDEN BERG 3,057,007

PROBING MACHINE

Filed Feb. 29, 1960 6 Sheets-Sheet 1

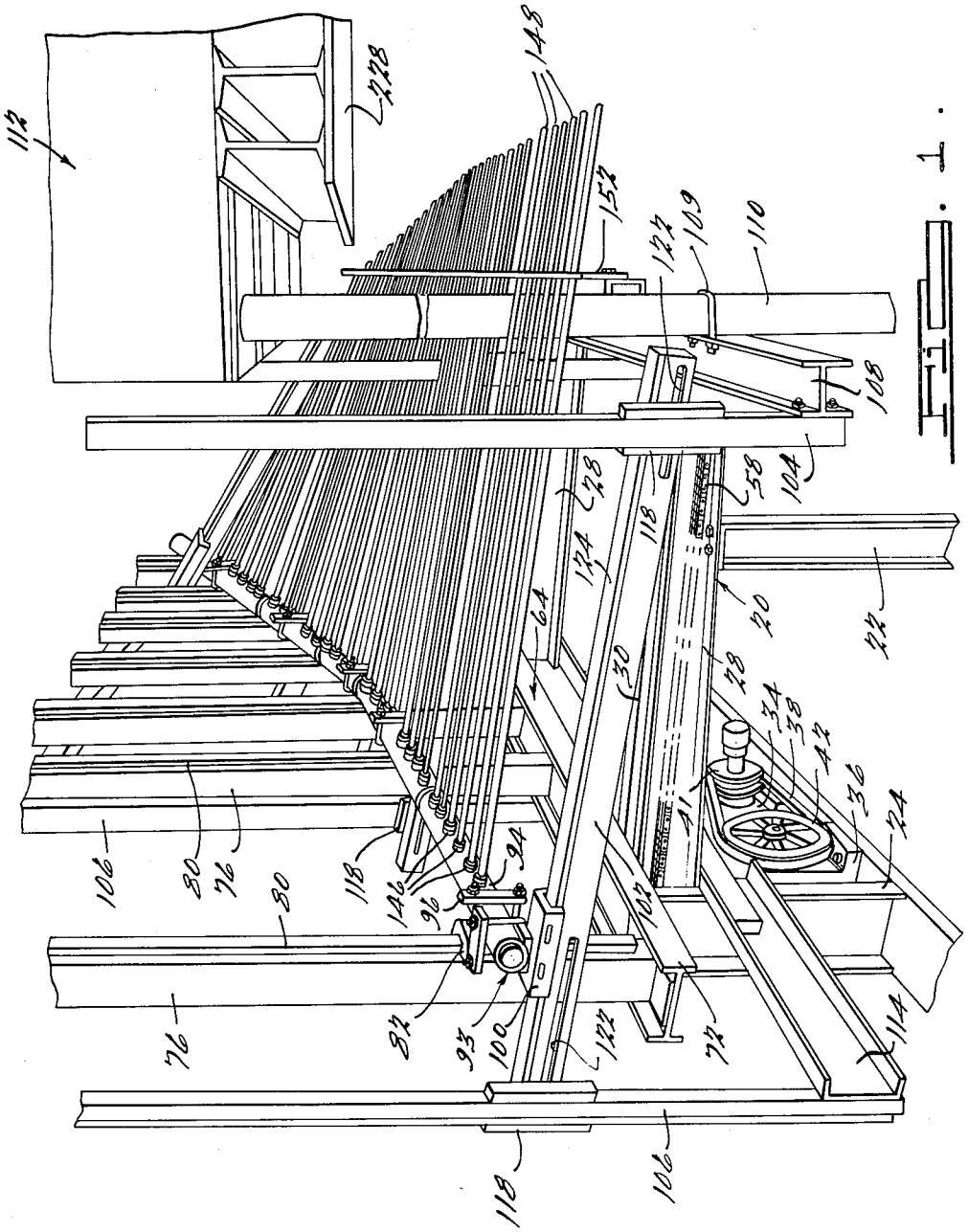

FIG. 1.

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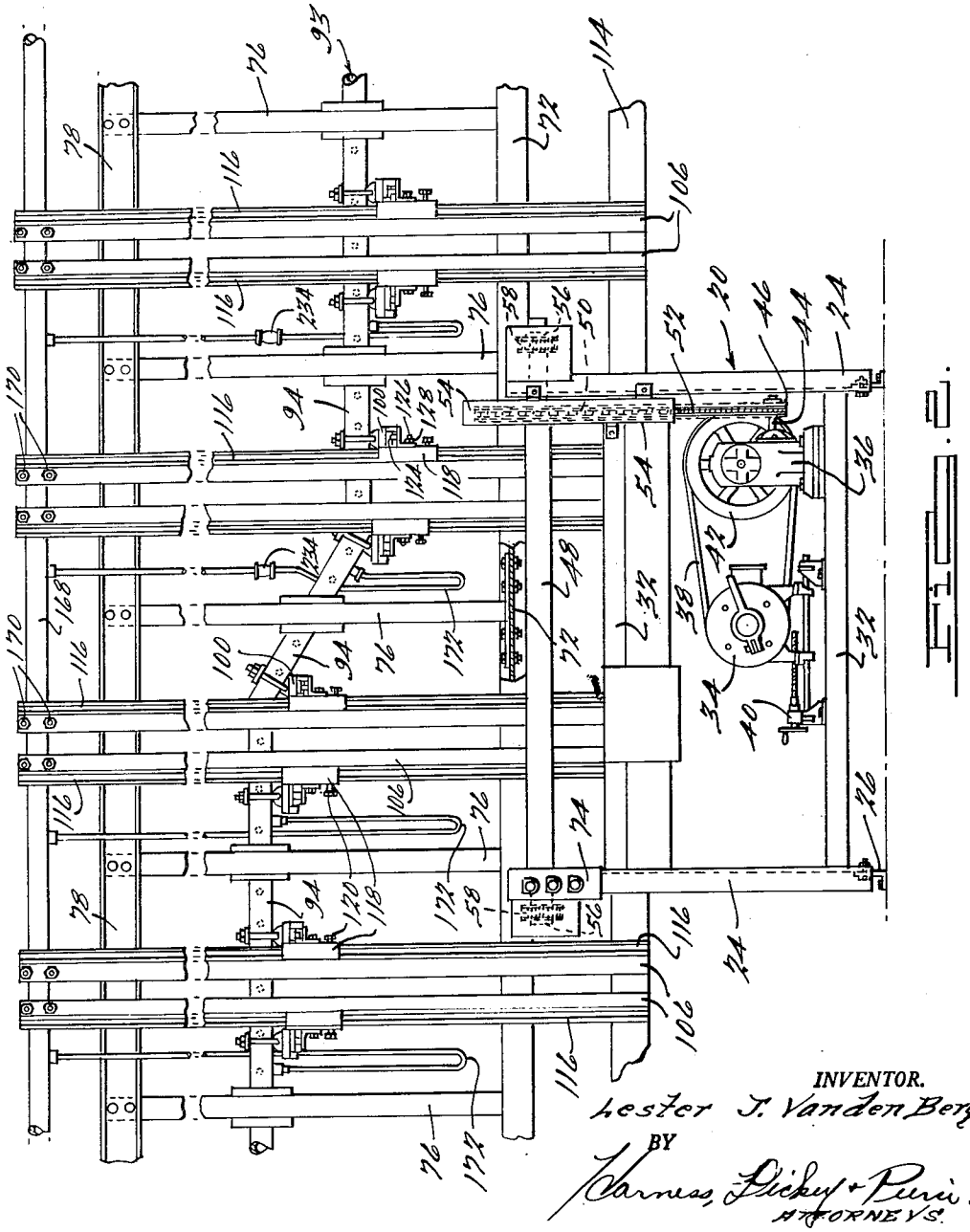
Filed Feb. 29, 1960 6 Sheets-Sheet 2



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PROBING MACHINE

Filed Feb. 29, 1960 6 Sheets-Sheet 3

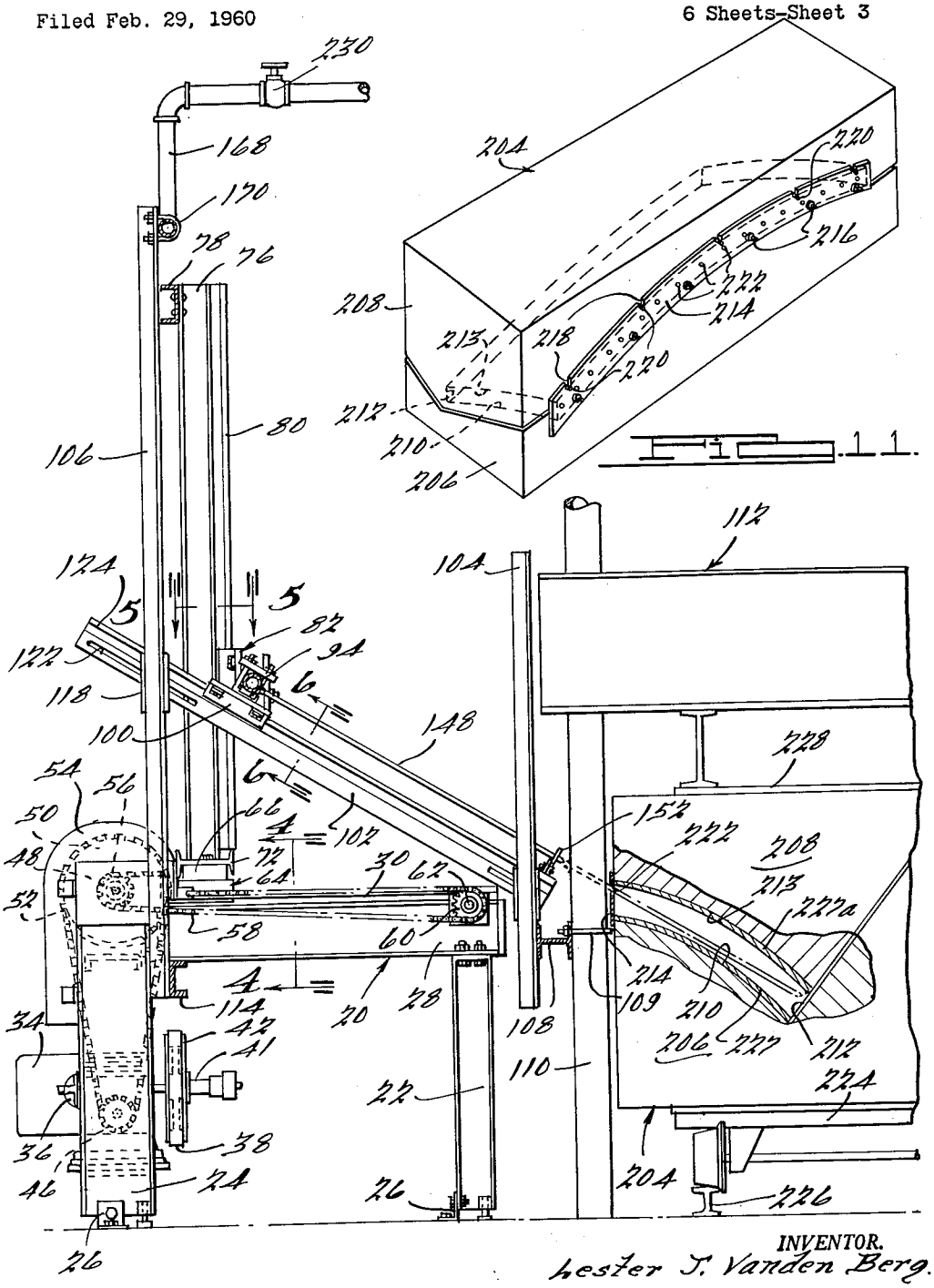

FIG. 11.

FIG. 3.

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PROBING MACHINE

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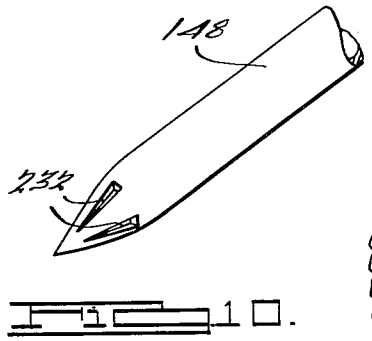

FIG. 1.

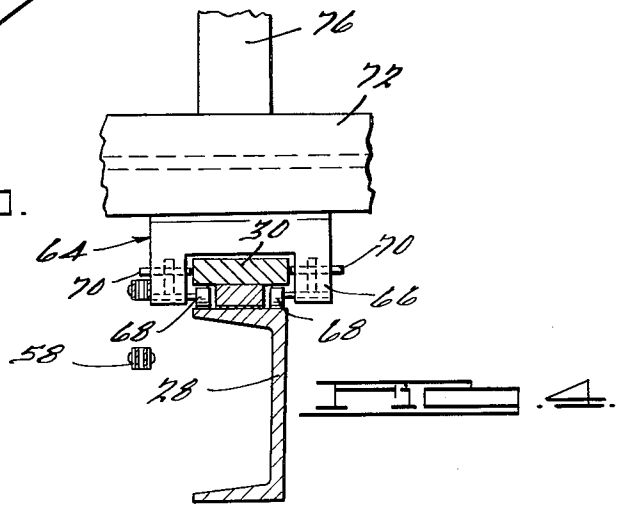

FIG. 4.

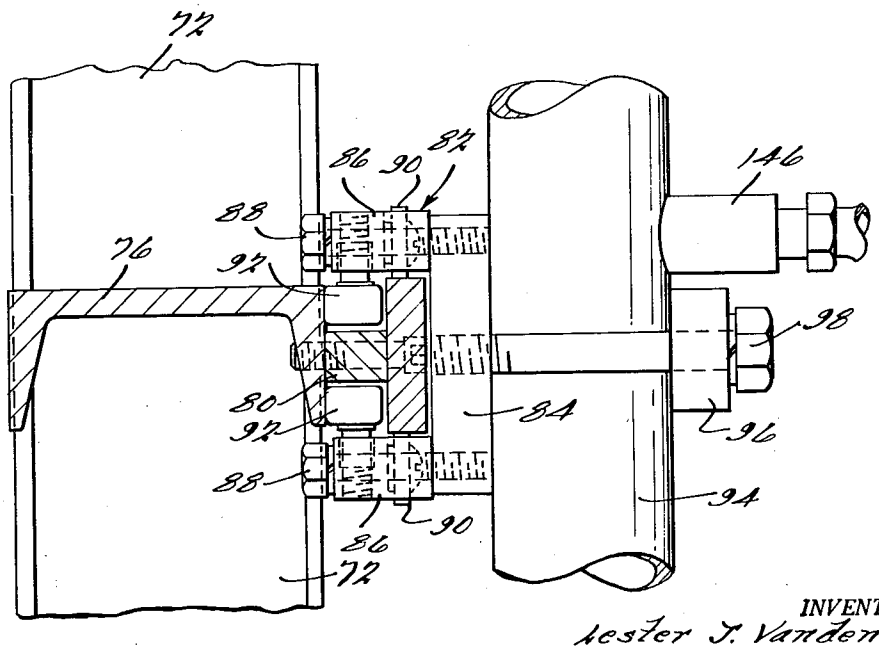

FIG. 5.

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PROBING MACHINE

Filed Feb. 29, 1960 6 Sheets-Sheet 5

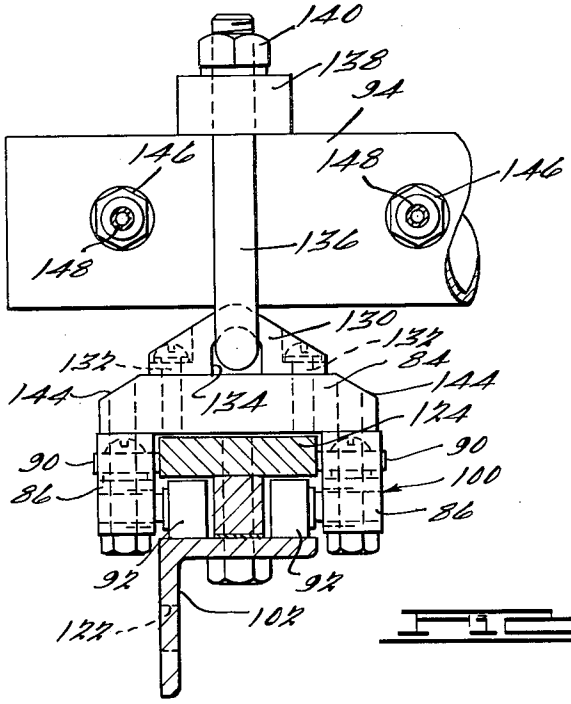

FIG. 5.

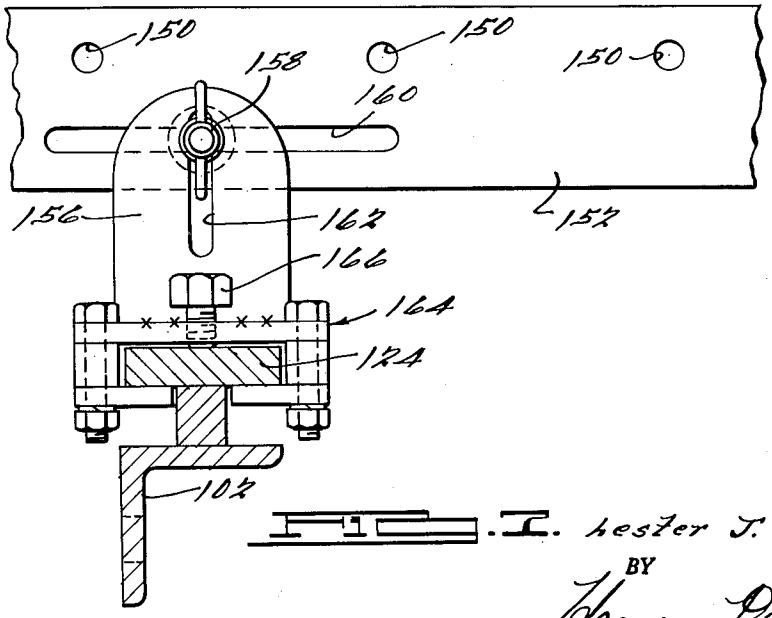

FIG. 6.

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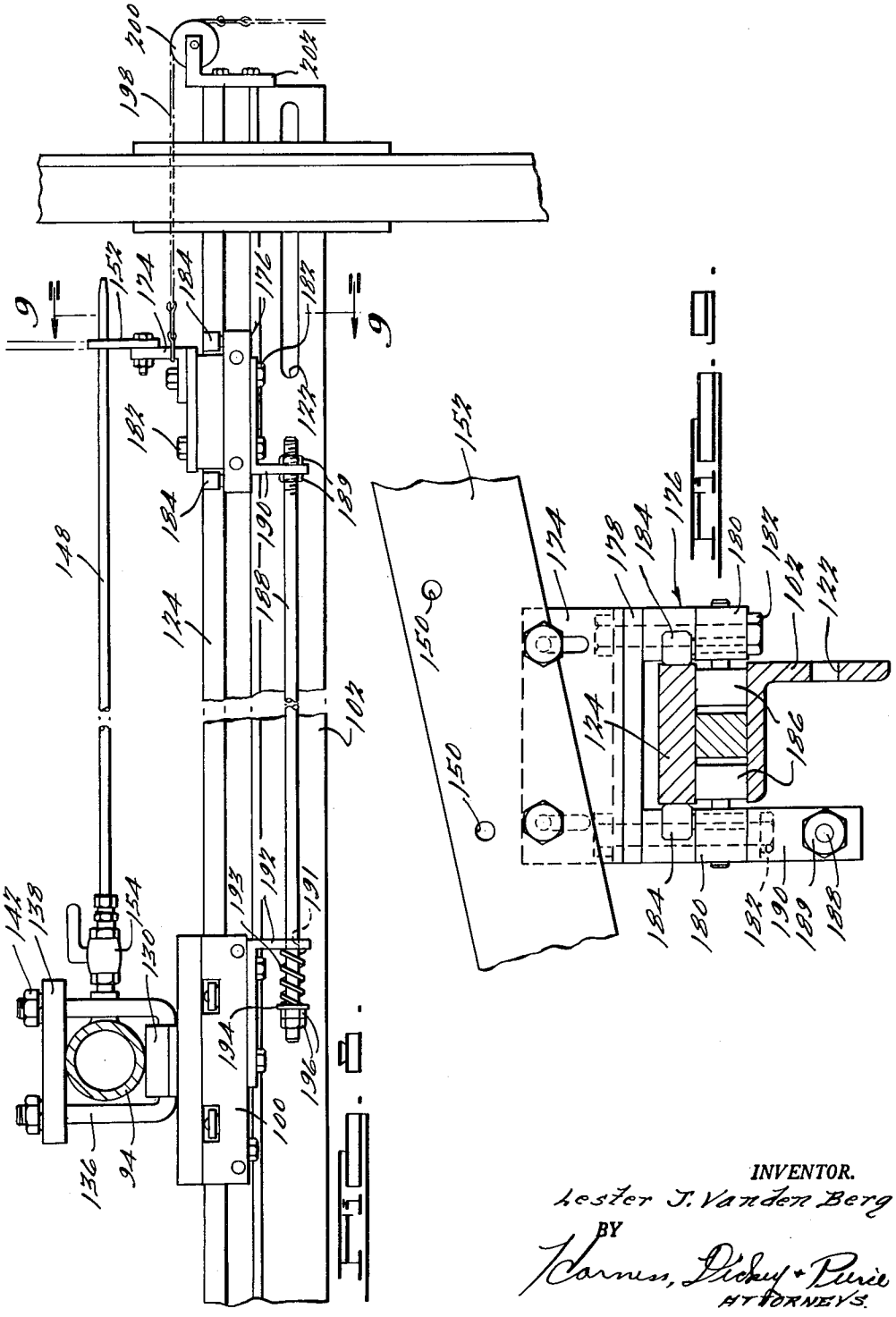
PROBING MACHINE

Filed Feb. 29, 1960 6 Sheets-Sheet 6



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3,057,007

PROBING MACHINE

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Filed Feb. 29, 1960, Ser. No. 11,511
6 Claims. (Cl. 18—1)

This invention pertains to a probing machine for simultaneously advancing a plurality of probe elements which are adjustably positionable through a directionally guided line of travel.

The principles of this invention are particularly applicable to a machine suitable for manufacturing nonplanar sandwich panels of a preselected contour which comprise a light weight foamed resinous core and more dense facing or cover sheets secured to the face surfaces of the core. Sandwich panels of this general type are now well known and their light weight, structural rigidity, and excellent thermal and sound insulating properties make them ideally suitable for assembly into complete articles such as boats, swimming pools, vehicle bodies, refrigeration enclosures, building structures of various types, etc.

Generally, sandwich panels of a planar configuration can be commercially fabricated from separately preformed cores and cover sheets which are assembled and adhesively secured together into a unitary panel. Nonplanar panels, however, particularly panels having compound curvatures are difficult to manufacture from preformed cores and preformed cover sheets of the desired contour and with sufficient accuracy to assure easy assembly with mating contoured surfaces. Moreover, cutting an appropriate preformed core from a larger piece is wasteful of both labor and raw material, and therefore constitutes an inefficient and expensive mode of manufacture. In addition, the successive manufacture of nonplanar panels having identical contoured surfaces requires exacting manufacturing and assembly techniques further detracting from the efficiency and economical production of nonplanar panels. One specific embodiment of the present invention overcomes the foregoing problems by providing a machine for simultaneously and uniformly expanding a thermoplastic resinous material between appropriately contoured cover sheets forming therewith a unitary panel.

In accordance with this manufacturing method for forming nonplanar panels, one or more dense planar cover sheets are positioned in a mold having a preselected contour with the outer surface of the cover sheets being positioned in contact with the adjacent mold surfaces and filling the cavity between the cover sheets with a partially expanded synthetic resinous material in a bead or pellet form. Appropriately positioned probes are then inserted into the resinous material between the cover sheets and a hot fluid such as air, superheated steam, or combinations thereof, is injected into the cavity from the probes whereby the resinous beads are expanded and united together and to the interior surfaces of the cover sheets thereby forming a unitary composite panel that permanently retains the curvature of the mold surfaces. Thermoplastic resinous materials suitable for forming a foamed core between two cover sheets include polystyrene, polyvinyl chloride, polyvinylidene, polyvinylidene chloride, polyacrylic esters, polymethacrylic esters, polyacrylonitrile, styrene-butadiene interpolymers, etc., and of this group polystryene represents a preferred material. The synthetic resinous materials in a bead or pellet form are pre-expanded to an approximate density ranging from about one-half pound to about ten pounds per cubic foot in a drum-type pre-expander having suitable agitation means therein and a heating source such as steam which is controllable in quantity and heat content to expand the beads to the desired density. To effect a foaming of the synthetic resinous materials an organic raising agent is employed which may be a low boiling point hydrocarbon, boiling in the range of about 85 F. to about 160° F. such as pentane, hexane, heptane, petroleum ether, cyclopentane, cyclohexane, etc., and which raising agents represent between about five percent to about twenty percent by weight of the resinous beads. Final expansion and fushion of the resinous beads in the cavity of the mold is achieved by inserting the probes of the probing machine and injecting a heated fluid whereby the temperature within the cavity is elevated to a range of about 275° F. to about 285° F.

As the size and complexity of curvature of the panels increase it becomes increasingly difficult to manufacture cores having uniform pore size of the expanded resinous core and which is free from fisures or areas of poor adhesion to the cover sheets. The probing machine of this invention overcomes these difficulties by directionally guiding each of the plurality of probes between the curved cover sheets and withdrawing them at a controlled rate whereby a uniformly expanded core securely bonded to the cover sheets is obtained.

Another objective of this invention is to provide a probing machine that is simply and quickly adjustable so that the angularity of the line of travel of each of the probing elements can be adjusted to any preselected position. Extreme flexibility of the probing machine is thereby achieved, whereby nonplanar panels of a variety of different sizes and curvatures are adaptable for manufacture by this machine. Once the machine is adjusted for a particular curvature as defined by the angularity of the path of travel of each of the probes, a series of curved sandwich panels can be manufactured in rapid succession which have identically contoured surfaces.

Still another object of this invention is to provide a probing machine that is of durable construction, simple in operation and substantially free of malfunctioning components.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the following drawings, wherein:

FIGURE 1 is a perspective view of a probing machine constructed in accordance with the preferred embodiments of this invention;

FIG. 2 is a fragmentary rear elevation view of the probing machine shown in FIG. 1;

FIG. 3 is a side elevation view of the probing machine shown in FIG. 2 and positioned in relation to a mold of, for example, the compound curvature type disposed adjacent to and longitudinally of the machine;

FIG. 4 is a vertical longitudinal sectional view through the carriage trackway of the base frame shown in FIG. 3 and taken along line 4—4 thereof;

FIG. 5 is a horizontal sectional view through an upright carriage column shown in FIG. 3 and taken along line 5—5 thereof;

FIG. 6 is a transverse sectional view through a manifold slideway shown in FIG. 3 and taken along line 6—6 thereof;

FIG. 7 is a fragmentary elevational view of the forward probe guide plate and mounting bracket slidably positionable on the manifold slideway;

FIG. 8 is a side elevational view of a short probe and movable front guide assembly slidably mounted on a manifold slideway;

FIG. 9 is a transverse sectional view through the manifold slideway showing in particular the movable front guide assembly shown in FIG. 8 and taken along line 9—9 thereof;

FIG. 10 is an enlarged fragmentary perspective view of

a probe and showing in particular the apertures disposed in the forward end portion thereof; and

FIG. 11 is a perspective view of a typical curved mold adaptable for the manufacture of nonplanar sandwich panels.

Referring now to the drawings, and as may best be seen in FIGS. 1–3, a probing machine incorporating the preferred embodiments of this invention is comprised of a base frame 20 on which a super structure is stationarily and movably mounted for supporting and guiding a plurality of probes through a preselected path of travel. Base frame 20 is comprised of a series of front legs 22 and rear legs 24 of a channel cross-section which are rigidly secured at their lower ends to the floor or other suitable foundation by means of anchor brackets 26. Transverse channels 28 are rigidly supported on front legs 22 and rear legs 24, the upper surfaces of which are provided with a T-shaped trackway or rail 30 rigidly secured thereto. A pair of longitudinal channels 32 are disposed horizontally between the inner surfaces of rear legs 24 and rigidly secured thereto. A suitable drive mechanism is mounted on lower longitudinal channel 32 such as electric motor 34 and variable speed reducer 36 drivingly connected together by flexible belt 38. Electric motor 34 is mounted on an adjustable motor base 40 which is rigidly secured to the upper surface of longitudinal channel 32. The output torque of motor 34 is transmitted to speed reducer 36 by flexible belt 38 extending around motor pulley 41 and speed reducer pulley 42 and which, through suitable reduction gearing is transmitted to transverse output shaft 44 having a drive sprocket 46 fixedly mounted thereon. Shaft 48 is disposed between and journaled through the upper end portions of rear legs 24 to which driven sprocket 50 is fixedly secured and in vertical alignment with drive sprocket 46. Sprocket chain 52 extends around drive sprocket 46 and driven sprocket 50 and is encased at its upper end by chain cover 54. Splined on the outer ends of shaft 48 are sprockets 56 each of which are in engagement with chains 58 extending around a similar pair of idler sprockets 60 rotatably mounted on fixed shafts 62 secured to the forward end portions of transverse channel 28 and in transverse alignment with sprockets 56. The ends of chains 58 are secured to carriage 64 which is longitudinally disposed on the base frame 20 and movably mounted on T-track 30 as may be best seen in FIG. 4. As shown therein, carriage 64 is comprised of an inverted U-shaped member 66 having a pair of transverse rollers 68 extending inwardly from each of the depending side flanges thereof and adapted to alternately contact the upper surface of transverse channel 28 and inner surface of T-rail 30. Side rollers 70 are horizontally disposed and rotatably mounted in each of the depending flanges of U-shaped bracket 66 and are adapted to contact the side edges of rail 30 maintaining carriage 64 in appropriate alignment therewith. A horizontal I-beam 72 is rigidly secured to the upper surface of each of U-shaped brackets 66 and provides the supporting base for the movable super structure above.

The carriage driving mechanism is provided with a suitable start-stop-reverse push button switch 74 whereby carriage 64 is caused to move laterally between a forward position and a rear position along T-rail 30. The lateral movement of carriage 64 between the forward and rear positions may be controlled by a pair of suitable limit switches (not shown) longitudinally positionable along T-rail 30 and actuable in response to the movement of the carriage 64 therealong. Actuation of the forward or rear limit switch would automatically de-energize electric drive motor 34 thereby halting the lateral movement of carriage 64 in the appropriate forward or rearward position, respectively. Energization of motor 34 is achieved by manually depressing a push button of switch 74 which overrides either limit switch and maintaining the push button depressed until carriage 64 has moved sufficiently to release the limit switch.

A series of upright columns 76 are fixedly secured at spaced intervals to the web portion of longitudinal I-beam 72 by welding, bolting or the like. Upright columns 76 are reinforced by a longitudinal channel stringer 78 extending along the upper portions of the columns and rigidly secured to the rearward surfaces thereof. The forward vertical edge of upright column 76 is provided with a T-shaped rail 80 extending substantially the entire length thereof and along which roller bracket 82 is movably mounted. As may be best seen in FIG. 5, roller carriage 82 is comprised of a base plate 84 and rectangular depending leg portions 86 disposed in parallel spaced relation and rigidly secured to the side edge surfaces of base plate 84 by securing means such as screws 88. The inner portions of legs 86 are provided with a pair of side rollers 90 which are adapted to roll along the side portion of T-shaped rail 80 maintaining roller bracket 82 in transverse alignment therewith. In addition, a pair of transverse rollers 92 extending inwardly from each leg 86 are adapted to alternately bear against the forward vertical surface of upright column 76 and the inner parallel surface of T-rail 80 interlocking roller bracket 82 with T-rail 80 and limiting its lateral movement with respect thereto. Manifold pipe section 94 is securely clamped to the forward surface of base plate 84 by means of transverse strap 96 overlying the forward surface of manifold section 94 and secured to base plate 84 by bolts 98 in threaded engagement therewith. By this arrangement the lateral movement of carriage 64 is transmitted to manifold section 94 movably mounted on vertical column 76.

As shown in FIGS. 1 to 3, the composite header or manifold 93 is comprised of a series of manifold sections 94 sealed at their ends and disposed in spaced substantial end to end alignment with adjacent sections and extending longitudinally along the machine. The mid-point of each manifold section 94 is secured to roller bracket 82 as heretofore described, which is vertically movable along the forward surfaces of upright columns 76. Each of the end portions of manifold sections 94 are movably supported on slide brackets 100 movably mounted on slideways 102 disposed in parallel spaced relation and extending between the forward and rearward portions of the base frame 20. The forward and rearward ends of slideways 102 are connected to and adjustably positionable on vertical front and rear supports 104 and 106 respectively. The lower portions of vertical front supports 104 are rigidly affixed to longitudinal I-beam 108 which is rigidly supported along the front portion of the base frame, such as by U-bolts 109 affixed to posts 110 comprising a portion of press 112 disposed along the front of the probing machine. The rear supports 106 are fixedly mounted in a vertical position having the lower ends thereof rigidly secured to longitudinal channel brace 114 extending along the rear portion of the base frame and secured to rear legs 24 and transverse channels 28. Front supports 104 and rear supports 106 are comprised of angle iron structural elements and are disposed in pairs with the projecting flanges thereof in opposing spaced relationship and to which are secured T-shaped slide tracks 116. Slidably mounted on each slide track 116 is a U-shaped slide shoe 118 which is adjustably positionable therealong and locked with respect thereto by locking screws 120.

Slideways 102 are of a similar construction to front and rear supports 104 and 106, respectively, comprising an angle iron stringer having elongated slots 122 disposed along each end portion of the vertical flange thereof and a T-rail 124 fixedly secured to the horizontal flange surface on which slide brackets 100 are movably mounted. Slideways 102 are adjustably affixed to slide shoes 118 by stud 126 secured to shoe 118 that extends through slot 122 of slideway 102 and is provided with securing nut 128 in threaded engagement therewith as may be

best seen in FIG. 2. The adjustability of slide shoes **118** along vertical front and rear supports **104** and **106**, respectively, coupled with the slidable connection provided by slots **122** in slide rail **102** enables each slide rail to be independently and angularly positionable in a vertical transverse plane. Accordingly, by adjusting the angularity of each pair of slideways **102** the appropriate longitudinal inclination of manifold sections **94** can be obtained. To permit substantial angular deflections of manifold sections **94** the ends thereof are pivotally mounted on slide brackets **100**, as may be best seen in FIG. 6. Slide bracket **100** is similar in construction to roller bracket **82** comprising a base plate **84** having depending leg portions **86** secured thereto. The side legs **86** incorporate pairs of side rollers **90** and transverse rollers **92** to minimize friction and guide slide bracket **100** along T-rail **124**. The upper surface of base plate **84** is provided with pivot block **130** secured thereto by recessed screws **132**. Pivot block **130** is of a triangular configuration having the apex thereof disposed substantially at right angles to the longitudinal center line of manifold section **94** and in tangential contact with the periphery thereof. An aperture or groove **134** extends longitudinally through the base of a pivot block **130** in which the bight portion of U-clamp **136** is pivotally mounted. The leg portions of U-clamp **136** extend upwardly through transverse strap **138** and have nuts **140** in threaded engagement with the ends thereof clamping manifold section **94** against pivot block **130**. The upper edge portions of base plate **84** may be chamfered as at **144** to enable unrestricted pivotal movement of manifold section **94**.

A plurality of fittings such as pipe couplings **146** are rigidly secured at spaced intervals along the forward edge of manifold section **94** having the interiors thereof communicating with the interior of the manifold section. A tubular probe **148** is connected to each coupling **146** and is slidably supported along its forward end by aperture **150** in probe guide plate **152**. Each probe may be provided with a suitable variable flow valve **154** (FIG. 8) whereby the discharge of the heated fluid from manifold section **94** through the probe can be regulated to any desired volume.

Probe guide plate **152**, as may be best seen in FIG. 7, is adjustably mounted to upstanding bracket **156** by a screw and wing nut assembly **158**. Transverse slot **160** in probe guide plate **152** and vertical slot **162** in upstanding bracket **156** enables guide plate **152** to be vertically and angularly positionable with respect to slideways **102**. Upstanding bracket **156** is rigidly secured to slide clamp **164** adjustably slidable along T-rail **124** and locked thereto by lock screw **166**. By this arrangement probe guide plate sections **152** corresponding in length to manifold sections **94** may be positioned along slideways **102** and angularly inclined therebetween so as to provide continuous guided support of probes **148** during their forward and rearward travel.

In the specific embodiments of this invention herein described probes **148** are adapted to be inserted within the cavity of a compound curvature mold ejecting a heated fluid from the end portions thereof whereby resinous pre-expanded beads contained within the cavity are united into a unitary core. The heated fluid is supplied to each of the manifold sections **94** from a main supply line **168** which extends longitudinally above the machine and is secured to the upper ends of rear supports **106** by clamping means such as U-bolts **170**. Main supply line **168** is connected to each manifold section **94** by suitable flexible pipe means or hoses **172** of a length sufficient to permit unrestricted forward travel of the manifold sections. Although compressed heated air provides a satisfactory means for expanding the prefoamed resinous beads the preferred practice utilizes a superheated steam supplied at a line pressure of between about thirty to about one hundred pounds per square inch, which is

introduced into the cavity from apertures or jets disposed in the forward end of the probes **148**.

The lengths of probes **148** extending transversely from manifold sections **94** vary in length to accommodate variations in the depth or breadth of the mold cavity. All the probes are simultaneously advanced toward the mold during the forward lateral movement of the composite manifold from its rearward position. In the manufacture of nonplanar panels which deviate substantially in depth, it may be necessary to employ probes along sections of the machine that are shorter in length than the lateral stroke or travel of composite manifold and carriage **64**. Under these circumstances, the short probes would be withdrawn from apertures **150** in guide plates **152** adjustably mounted on the forward portions of slideways **102** leaving the probes unsupported and unguided for the next forward stroke. Moving slide clamps **164** rearward along slideways **102** to compensate for the short length of the probes would cause interference between slide brackets **100** and slide clamps **164** during the forward movement of the composite manifold. Accordingly, it is necessary to provide movable front probe guides along those portions of the probing machine wherein short guides are disposed which provide continuous guidance of the probes and yet will not interfere with the forward travel of slide bracket **100** along slideway **102**. A satisfactory movable probe guide assembly is illustrated in FIGS. 8 and 9. Probe guide plate **152** is adjustably mounted on upstanding bracket **174** secured to the upper surface of guide roller bracket **176**, which is movably mounted on T-rail **124**. Guide roller bracket **176** is comprised of a base plate **178** to which side leg portions **180** disposed in spaced parallel relation are securely attached by means of screws **182**. A pair of side rollers **184** are rotatably mounted on each side leg **180** and are adapted to contact the side portions of T-rail **124**. Transverse rollers **186** extend inwardly and are disposed between the upper surface of the angle iron stringer of slideway **102** and the inner surface of T-rail **124** thereby laterally and longitudinally aligning guide roller bracket **176** along slideways **102**. A tie rod **188** extends between slide bracket **100** and guide roller bracket **176** and is adjustably connected at its forward end by lock nuts **189** to the depending flange of angle bracket **190** secured to the lower portion of one of the legs **180** of guide roller bracket **176**. The other end of the tie rod **188** extends through aperture **191** in depending flange of angle bracket **192** secured to the lower portion of slide bracket **100**. Coil spring **193** extends around the end of tie rod **188** having the forward portion thereof in abutting relation with the rearward surface of the depending flange of angle bracket **192** and the rearward portion thereof in abutting relationship with washer **194** held in position by lock nuts **196** in threaded engagement with the ends of tie rod **188**. Guide roller bracket **176** is biased toward the forward end of slideway **102** by a flexible element such as link chain **198** connected to guide roller bracket **176** and extending over sheave **200** rotatably mounted on angle bracket **202** secured to the forward end of slideway **102**. The lower end of chain **198** (not shown) is weighted whereby a constant force is applied to guide roller bracket **176** biasing it toward the front portion of slideway **102**. In operation, as carriage **64** moves forward manifold section **94** and slide bracket **100** also moves forward along slideway **102** and guide roller bracket **176** simultaneously moves along slideway **102** in constant spaced relation to slide bracket **100** with probes **148** supported in guide plate **152**. When the forward end of guide roller bracket **176** contacts angle bracket **202** disposed at the forward end of T-rail **124** its forward motion ceases and slide bracket **100** continues to move forward whereby the rod **188** slides through the aperture **191** in angle bracket **192** and probes **148** slide forward through apertures **150** in guide plate **152**. After a predetermined period in the forward position, the composite

manifold 93 is retracted whereby probes 148 and slide roller brackets 100 move toward the rearward position and during which movement the depending flange of angle bracket 192 comes into abutting relationship with coil spring 193 which cushions the engagement of guide roller bracket 176 and gradually accelerates it from a standing position at the forward end of T-rail 124. Guide roller bracket 176 is pulled rearward by tie rod 188 in opposition to the biasing force applied thereto by weighted chain 198 until the probing machine again returns to its rearward position. It will of course be appreciated that the length of tie rod 188 can be varied in accordance with the length of the probe 148 depending on the breadth of the specific panel being formed.

A typical mold for manufacturing nonplanar sandwich panels in conjunction with the probing machine herein described, may be best seen in FIGS. 3 and 11. As shown therein, mold 204 is comprised of a lower female portion 206 and an upper male portion 208 in overlying indexed relationship therewith. Female mold section 206 is provided with a contoured surface 210 which defines the curvature of one surface of the nonplanar panel and an internal end surface 212 defining the end and breadth of the nonplanar panel. Male mold portion 208 is provided with contoured surface 213 correspondingly contoured and spaced from surface 210 of the female mold portion, which together with end surface 212 defines a cavity having a configuration corresponding to the finished sandwich panel. The exterior edge surface of the mold cavity is defined by a front closure plate 214 overlying the side surfaces of the male and female mold portions and is secured along its lower edge to the female mold portion 206 by a plurality of bolts 216 spaced therealong. The upper edge portion of plate 214 is provided with a plurality of receiving apertures 218 disposed at spaced intervals and corresponding to the spacing of locating pins 220 affixed to the side of male mold portion 208. The coaction between locating pins 220 and receiving apertures 218 serves to align and support the upper mold portion in its lowered position over lower female mold portion 206. Suitable gasketing material may be disposed on engaging surfaces between upper and lower mold portions and on the rearward face of closure plate 214 to effect a pressure tight seal of the mold cavity. Front closure plate 214 is provided with a plurality of apertures 222 disposed at spaced intervals therealong and coinciding with the spacing of probes 148 of the probing machine which are in adjustable alignment therewith.

Preparatory to the formation of a panel, the mold is assembled by first placing the lower female mold portion 206 on a suitable base such as cart 224 movably mounted on a trackway 226 extending adjacent to and longitudinally of the front side of the probing machine. The lower mold surface 210 is then covered with a suitable facing sheet 227 the upper surface of which has been coated with a suitable adhesive. A plurality of prefoamed spacer blocks preferably of the same composition as the resinous beads to be employed, and having the approximate desired core thickness are positioned on the adhesive of the cover sheet and spaced over the surface. A second cover sheet 227*a* having the inner surface thereof coated with a similar adhesive is placed over the spacer blocks with the adhesive layer in contact therewith and the upper mold portion 208 is lowered into position and in engagement with lower mold portion 206. During the lowering of upper mold portion 208 the cover sheets 227, 227*a* deflect and assume the curvature of the upper and lower mold surfaces 210 and 213, respectively, and are maintained in that curvature by the spacer blocks disposed therebetween. Alternatively, the cover sheets 227, 227*a* may be detachably secured by suitable securing means to the upper and lower mold surfaces 210 and 213, respectively, prior to the lowering of the upper mold whereby the cover sheets are held in the appropriately contoured positions. The mold is clamped together and the cavity is then filled with a quantity of pre-expanded resinous beads as heretofore described by injecting the same through, for example, apertures 222, preferably through a nozzle using air as the propelling means. The clamped and assembled mold is then moved into position longitudinally of the forward end of the probing machine and the lower platen 224 of press 112 is raised maintaining contacting upper and lower mold surfaces in firm abutting relationship.

With the assembled mold 204 in appropriate alignment along the front side of the probing machine, the forward probe guide plate 152 for each header section and each corresponding pair of slideways 102 are adjusted so that each of the probes 148 are in axial alignment with the corresponding probe aperture 222 in the front closure plate 214. In addition, the transverse angularity of slideways 102 and longitudinal inclination of manifold sections 94 are adjusted so that the line of travel of the probe passes through substantially the midpoint of the resin filled cavity of the mold without interfering with either of the exterior cover sheets. Drive motor 34 is then energized causing carriage 64 to move forward whereby the probes are simultaneously inserted into the resin filled mold cavity until the forward ends thereof are adjacent to the interior end surface 212. Main control valve 230 disposed in the main supply line 168 which may be solenoid actuated is then opened permitting a pressurized heated fluid to be discharged from the ends of probes 148 into the mold cavity.

Injection of the heated fluid into the mold cavity may be achieved by a plurality of apertures or jets peripherally disposed around the forward portion of the probe 148, and offset from the apertures in adjacent probes so as to provide optimum distribution of the heated fluid throughout the adjacent space. In lieu of a plurality of peripheral positioned apertures along the forward length of the probe, the preferred probe construction utilizes a series of jets 232 spaced around the tapered forward end surface of the probe as shown in FIG. 10. The jets 232 as shown, are triangular in shape and the sides thereof taper inwardly from the base of the triangle to the apex which is located at or immediately adjacent to the end extremity of the probe, and disposed in the tapered end surface portion thereof. Four jets 232 disposed 90° apart have been satisfactorily employed although a smaller or larger number could be used. In a typical commercial probe, the width of the base portion of triangular jet 232 may be about $\frac{1}{64}$ to about $\frac{1}{32}$ of an inch, and the height of the triangular jet may be about $\frac{1}{8}$ to about $\frac{1}{4}$ inches. The tapered end portion of each probe 148 provides a peripheral cam surface facilitating alignment of the probe with probe apertures 222 during the insertion of the probes and reduces the force required to advance them through the resin filled mold cavity.

After the discharge of the heated fluid for a predetermined time interval while the probing machine is in the fully forward position electric drive motor 34 is energized slowly withdrawing the probes at a uniform rate to effect a fusion and consolidation of the resinous beads and adhering them to the surfaces of the exterior cover sheets. In the preferred practice, a superheated steam is employed to heat the resinous beads within the mold cavity and minimize the entrapment of moisture therein. It will be apparent of course, that probes 148 occupy a space within the expanding resinous bead which would represent voids or discontinuities in the final core unless the beads are expanded to fill this space as the probes are withdrawn from the cavity. Accordingly, by maintaining a constant discharge of steam from jets 232 and withdrawing the probes at a rate sufficiently slow to cause the beads to expand and fill the space formerly occupied by the probe, a homogeneous core can be obtained devoid of any discontinuities therein. Moreover, the discharge of steam is preferably continued until

the ends of the probes are completely withdrawn from the cavity to ensure that the exterior end surface of the core is uniformly filled with expanded beads.

The amount of heat necessary to form a homogeneous expanded core is dependent on the specific resin utilized for forming the core. Preliminarily expanded resinous beads of a polystyrene type resin for example, are effectively interfused at a temperature ranging from about 275° F. to about 285° F. Moreover, the quantity of heat supplied per unit volume of resinous materials should be substantially equal throughout the entire length and breadth of the panel to achieve uniform pore size. Accordingly, panels varying in thickness and breadth throughout their length and consequently varying in the volume of resinous beads disposed between the exterior cover sheets can be satisfactorily expanded by controlling the time and/or the pressure of steam supplied to the probes at various stations along the panel. Installation of suitable pressure-flow control valves **234** (FIG. 2) in each of the flexible pipe means **172** supplying the superheated steam to each of the manifold sections **94** of the composite manifold coupled with the variable flow valves **154** connected to each individual probe **148** provides means whereby the duration and pressure of steam ejected from each probe can be regulated to the desired magnitude. By this arrangement, the control valves **234** connecting each of a selected number of manifold sections **94** disposed adjacent the thicker sections of the panel may be opened at a predetermined time interval prior to that of the other valves and at a higher pressure setting to provide the appropriate quantity of heat required to interfuse the greater volume of resinous beads. While it is difficult to state a definite relationship between the pressure of steam ejected from each probe, time delays between applying steam to selected manifold sections, and the rate at which the probes are withdrawn from the cavity in the manufacture of nonplanar panels of various curvatures and configurations, the application of the foregoing principles to a specific panel and conducting a few trial runs will establish optimum operating conditions. It is desired, although not necessary for the satisfactory operation of the machine, to provide probe apertures **222** in the front mold closure plate **214** with a resilient gasket adapted to envelop the probe forming a slidable sealing surface that inhibits leakage of steam from the pressurized mold cavity while the probes are disposed in the mold cavity.

The extreme adjustability features of the probing machine herein described enables the manufacture of a variety of different nonpolar panels having complex curvatures and variations in the depth and thickness of the panel. For each specific panel the longitudinal inclination of each of the manifold sections **94** comprising the composite manifold **93** is adjusted to conform with the longitudinal curvature of the nonplanar panel to be manufactured. In addition, the transverse inclination of each of the probe elements is adjusted to the angle of inclination of the mold cavity as it changes from end to end in the panel. Each of the manifold sections **94** comprising the composite manifold need not necessarily be of the same length. Longer manifold sections **94** may be employed along sections of the nonplanar panel wherein the severity of the longitudinal curvature thereof is substantially small and conversely shorter manifold sections **94** are required to enable appropriate orientation of the probes along those sections where the severity of the longitudinal curvature of the panel is great. In lieu of substantially short manifold sections **94**, it will be appreciated that curved sections may be employed corresponding in shape substantially to the longitudinal curvature of the panel. In addition, the flexibility provided by the valving control means enables panels of varying length to be fabricated by this machine.

While it will be apparent that the preferred embodiments herein illustrated are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. A probing machine comprising a frame, a plurality of slideways disposed at longitudinally spaced intervals and independently adjustably mounted transversely of said frame, a plurality of manifold sections disposed in spaced substantially end to end relationship and extending longitudinally along said frame, each of the end portions of each of said manifold sections movably mounted on one of said slideways for guidably supporting said manifold sections and providing for independent adjustment of the longitudinal angularity thereof, a plurality of probes connected at spaced intervals to the forward portion of each of said manifold sections and extending transversely of said frame, guide means longitudinally disposed along the front portion of said frame for supporting and maintaining said probes in appropriate transverse orientation and moving means connected to each of said manifold sections operative to laterally move said sections along said slideways to and from a forward position and a rearward position.

2. A probing machine comprising a frame having a front portion and a rear portion, a plurality of slideways extending transversely at spaced intervals between said front and said rear portions of said frame and independently adjustably secured thereto, a plurality of manifold sections disposed in spaced substantially end to end relationship and extending longitudinally along said frame, each of the end portions of said manifold sections movably mounted on one of said slideways for guidably supporting said manifold sections and providing for independent adjustment of the longitudinal angularity thereof, a plurality of tubular probes connected at spaced intervals to the forward portion of each of said manifold sections and extending transversely of said frame toward the front portion thereof, the interiors of said probes communicating with the interiors of said manifold sections, a plurality of apertures in the forward end portion of each of said probes, guide means longitudinally mounted along the front portion of said frame for supporting and maintaining said probes in appropriate transverse orientation, pipe means connected to each of said manifold sections, and moving means associated with each of said manifold sections operative to laterally move said sections along said slideways to and from a forward position and a rearward position.

3. A probing machine comprising a base frame having a front portion and a rear portion, a carriage longitudinally disposed on said frame and laterally movable thereon to and from a rear position and a forward position, moving means associated with said carriage for laterally moving said carriage between said positions, a composite manifold comprising a plurality of manifold sections longitudinally disposed in spaced substantially end to end relationship along the length of said frame and movably mounted on said carriage and laterally movable thereby, a plurality of slideways transversely mounted on said frame and extending between said front and said rear portions thereof and independently angularly adjustable in a vertical plane, each of the end portions of each of said manifold sections slidably mounted on one of said slideways and movable therealong for guidably supporting said manifold sections and providing for independent adjustment of the longitudinal angularity thereof, a plurality of hollow probes disposed in spaced apart relation connected to the forward edge of each of said manifold sections and having the interiors thereof in communication with the interiors of said manifold sections, a plurality of discharge apertures in the forward end portion of each of said probes, probe guide means adjustably mounted along the front portion of said frame for slidably supporting said probes, flexible pipe means con-

nected to each of said manifold sections for supplying a pressurized fluid thereto, and valve means in said flexible pipe means and said probes for selectively regulating the pressure of fluid supplied to said probes.

4. A probing machine comprising a frame having a front portion and a rear portion, a carriage extending longitudinally along said frame and laterally movable thereon to and from a forward position and a rear position, moving means connected to said carriage for laterally moving said carriage in a horizontal plane between said positions, a plurality of upright columns mounted at spaced intervals along said carriage, a plurality of slideways extending transversely at spaced intervals between said front and said rear portions of said frame and adjustably secured thereto, a plurality of manifold sections disposed in spaced substantially end to end relationship and extending longitudinally along said frame, each of said manifold sections movably mounted substantially at the midpoint thereof to one of said upright carriage columns and each end portion of each of said sections movably mounted on one of said slideways, said slideways guidably supporting said manifold sections and providing for independent adjustment of the elevation and longitudinal angularity thereof, a plurality of tubular probes connected at spaced intervals to the forward portion of each of said manifold sections and extending transversely of said frame toward the front portion thereof, the interiors of said probes communicating with the interiors of said manifold sections, a plurality of apertures disposed in the forward end portion of each of said probes, guide means adjustably mounted longitudinally along the forward portion of said frame for slidably supporting and maintaining said probes in appropriate transverse orientation, flexible pipe means connected to each of said manifold sections for supplying a pressurized fluid thereto, and valve means in said pipe means for selectively regulating the pressure of fluid supplied to said probes.

5. The probing machine as described in claim 3, wherein at least a portion of said probe guide means comprise a movable probe guide assembly extending transversely of and movably mounted on the forward portions of a pair of said slideways and movable therealong, linkage means connecting said movable probe guide assembly and said manifold section and restricting the maximum lateral spacing therebetween to a distance less than the length of said probes, urging means associated with said movable probe guide assembly biasing said assembly toward the forward end of said pair of slideways, and stop means associated with said slideways and operative to coact with said movable probe guide assembly to limit the forwardmost travel thereof.

6. The probing machine as described in claim 4 wherein at least a portion of said guide means for supporting said probes comprise a movable probe guide assembly comprising a pair of guide roller brackets movably mounted on the forward portions of a pair of said slideways, a guide plate extending transversely between said pair of slideways and having each end portion thereof adjustably affixed to one of said guide roller brackets, a plurality of apertures longitudinally disposed at spaced intervals along said guide plate and adapted to slidably support said plurality of probes extending therethrough, linkage means connecting each of said guide roller brackets to said manifold section and restricting the maximum lateral spacing between said manifold section and said guide plate to a distance less than the length of said probes, urging means associated with each of said guide roller brackets biasing said brackets toward the forward ends of said slideways, and stop means associated with said slideways and operative to coact with said guide roller brackets to limit the forwardmost travel thereof.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

October 9, 1962

Patent No. 3,057,007

Lester J. Vanden Berg

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 66, for "polystryene" read -- polystyrene --; column 2, line 4, for "85 F." read -- 85° F. --; column 6, line 72, for "the", first occurrence, read -- tie --; column 9, line 28, for "the", first occurrence, read -- to --; line 50, for "nonpolar" read -- nonplanar --.

Signed and sealed this 16th day of July 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents