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(54) Screen cloth insertion apparatus and method

(57) An apparatus secures ventilation cloth (34) to a screen frame (30). A screen frame (30) is oriented in an approximately vertical position. The screen frame has a plurality of segments (30a-d). Each segment (30a-d) has a mounting surface (32a) on a face thereof. At least one of said segments (30a-d) has adhesive (36) on the mounting surface (32a) thereof. A ventilation cloth (34) is hung across the mounting surface (32a) of said one segment (30a-d). The adhesive (36) in said one of the segments (30a-d) is melted. The ventilation cloth (34) is inserted in the adhesive (36) across a length of said one of the segments (30a-d).

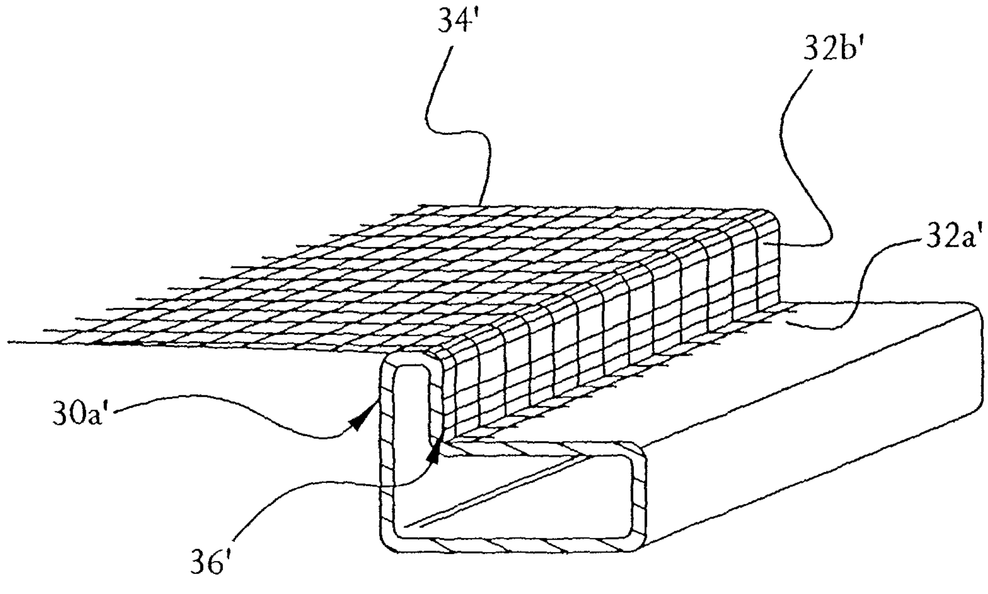

FIG. 9

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a screen and frame assembly for windows, doors and the like, and methods and apparatus for fabricating such frame assemblies.

BACKGROUND OF THE INVENTION

[0002] The general purpose of screens is to prevent the ingress of insects, while providing ventilation. A typical screen assembly is made up of screen cloth, fabric, or mesh attached to a screen frame in a manner discussed in more detail below. For brevity, the term "screen" is used herein, and includes such screen cloth, fabric, mesh or similar ventilation material.

[0003] Screen frames for windows, doors, operable skylights and the like are commonly made of four elongated frame members, called screen bars, of uniform cross section. These bars are typically roll-formed from aluminum or sheet steel, although some may be extruded aluminum. (Plastic and wood are also used, but to a lesser extent.) These screen bars are supplied from the screen bar manufacturer in lineal form and are cut to a final length by the screen assembly manufacturer. Further, these screen bars are held together at the corners with plastic or metal inserts, called comer keys, to form the screen frame.

[0004] Screen is then affixed to the screen frame to form a screen and frame assembly. These assemblies are then removably secured to windows, doors (e.g., patio screen doors), operable skylights, and the like.

[0005] It is desirable that the screen be a light-weight fabric or mesh, and stretched taut across the screen frame to avoid unsightly sag and to allow a viewer to see through the screen with minimal visual interference. However, if the screen is tensioned excessively, the screen bars deform inwardly in an hourglass shape. This resultant shape is not only aesthetically undesirable, but also can prevent proper installation in the window opening. Excess screen tension also increases the risk of tearing the screen during manufacture of the screen and frame assembly or while the assembly is in service.

[0006] Typically, the screen is fiberglass yarn or roving, which is coated, for example, with polyvinyl chloride (PVC), woven and heat fused. The next most popular form of screen is made by weaving drawn aluminum wire, which is subsequently painted. The PVC coated fiberglass screen is the most popular type, by approximately a 4 to 1 ratio (in area). However, both offer the desired attributes of suitable strength and an open weave.

[0007] To compensate for deformation of the screen frame into the hourglass shape discussed above, generally the screen bars are manufactured with an outward bow, in the plane of the screen, before the screen is installed. After the screen is installed into the screen bar by the manufacturer, its final tension straightens the frame members in the final assembly. This "pre-bow" is set into the screen frame during the extrusion or roll forming process to make the screen bar lineal.

[0008] Typically, roll-formed bar has approximately 20 millimeters (0.75 inches) of bow over a 3.7 meter (12 feet) length. Additional bow is usually set by hand into the roll-formed bar prior to screen installation when the length of the frame members is greater than 1 meter (approximately 3.5 feet). Pre-bowing is not generally required, however, when the screen bar is sufficiently rigid to resist deformation caused by the resultant screen tension.

[0009] It is the current practice to secure screen in open grooves formed along inside edges of the screen frames using a stuffer strip known as "spline" and its associated fastening techniques. The open grooves are known as "spline grooves." A spline is often a wire-like, extruded rigid plastic or foam material, although some splines are made from metal, especially for use with aluminum screens. A spline is usually round or T-shaped in cross section, but can be U-shaped, for example.

[0010] U.S. Patent No. 5,039,246 (the '246 patent) shows a conventional method of securing screen to a frame member using a spline. Using the reference numerals of the '246 patent, the spline 58 is forced into a spline groove or recess 56 in the screen bar 20, with the screen 22 sandwiched between the spline 58 and the spline groove 56.

[0011] The screen 22 is held by friction between the spline 58 and the spline groove 56 with the resulting interference fit. A lip 50 and a ledge 52, part way down one side of the groove wall, are typically included to help trap and improve the strength in retaining the screen 22. The spline 58 and trapped screen 22 are forced into the groove 56, usually by hand, with the use of a roller device 70, including a roller 72. The term, "hand wiring", is used to describe the action of securing the screen 22 with the spline 58 into the spline groove 56. Many attempts have been made to automate the installation of spline by machine. However, this automation has proven to be very difficult and machines of this nature have not been widely accepted as a viable option to hand wiring.

[0012] The conventional procedure for manufacturing and hand wiring a screen and frame assembly is discussed in more detail below. First, the screen bars are cut to length:, accounting for the corner key dimensions. Then, the screen frame is assembled using the cut screen bars and comer keys. As discussed above, when light construction screen bars are used, as is normally the case, a balance between pre-bow tension and screen tension is necessary to ensure straight screen bars and desirable tension in the final assembly. When the screen bar has insufficient pre-bow tension, the bars are deformed by hand a sufficient degree after the comer keys have been inserted. The amount of pre-bow is typically a few millimeters of bow per meter length of the screen bar.

[0013] The screen frame is then secured to a table using locator (stop) blocks, which prevent shifting and maintain the frame square during screen installation. The table typically has permanent stop blocks for orienting the screen frame. If the screen bar is not constrained, when the spline is inserted into the screen bar, excessive tension may be placed on the frame, causing the frame to hourglass inwards. To avoid hourglassing, removable blocks are located on the inside of the frame segment to limit deflection of the screen bar by the screen tension on assembly. (The spline groove must be facing up and unobstructed by the blocks.) More elaborate tables use removable blocks arranged in grooves cut into the table, with the removable blocks being secured by integral friction clamps. To avoid the need for blocking to prevent hourglassing, some manufacturers use extruded screen bar, instead of roll-formed screen bar, because of the greater strength of a (thicker) extruded section.

[0014] After the screen frame is secured to the table, the screen is pulled from a roll and positioned to cover the opening formed by the frame. Ideally, no excess screen is used, but this is difficult to achieve in practice. As a result, most manufacturers cut the screen approximately two inches (five centimeters) wider than the frame width, so that the screen is pulled past the end of the frame by approximately one inch (2.5 centimeters) to ensure that sufficient amount of screen can be rolled into the spline groove along the frame perimeter. In either technique, the screen is positioned over, with edges parallel to, the secured screen frame.

[0015] The screen and spline are installed into the spline groove by starting in one of the frame comers. The screen is then pulled taut at the next comer with one hand, keeping it straight and parallel to the edge of the mating screen bar. The spline is simultaneously held above the groove in the same manner as the screen, with the same hand. With the other hand, the installation roller is pushed along towards the upcoming comer with a firm downward force to push the spline and trap the screen into the spline groove. This action is repeated on the second and third screen bars. On the last screen bar, most of the tension is set into the screen. On this leg, the screen is pushed into the screen bar with the installer's finger, just prior to the insertion of the spline. This pre-insertion technique reduces the final tension in the screen to the desired level. The spline is cut at the final comer with a utility knife.

[0016] After the spline and screen are inserted in all screen bars, excess screen around the edge of the frame is cut away with a utility knife. The finished screen and frame assembly is removed from the table, inspected, and any necessary hardware is attached.

[0017] The current hand wiring process using spline has several drawbacks, however.

[0018] Current standards for screen and frame assemblies are established by associations such as the Screen Manufacturers Association (ANSI-SMA SMT 31-1990) in the United States and the General Standards Board in Canada (CAN-CGSB-79.1-M91). These standards cover particular elements of screen and frame assemblies for windows, patio doors and the like. Although these standards generally can be met by using the spline technology discussed above, very close and consistent dimensional tolerances are required between the spline and the spline groove, respectively, in order to achieve the specified fastening strength. These tolerances require close attention and skill with current screen bar roll-forming and extrusion technology and current spline hand wiring techniques. Any out-of-tolerance spline and screen bar produced costs the manufacturer in wasted time, material and goodwill.

[0019] Further, the amount of force required by an installer to secure the screen with the spline in the spline groove may be high enough to cause repetitive strain injury, e.g., carpal tunnel syndrome, to one who routinely performs this job. This is of major importance, since this type of injury is serious and has recently received heightened public awareness. Further, such an injury to an installer is also costly to the manufacturer in terms of compensation and loss of skilled labor.

[0020] Also, the hand wiring technique is particularly difficult and time-consuming. Notably, it is difficult to control the wire-like spline material and simultaneously control the screen tension with one hand, while the spline is rolled in with the other hand. This operation requires a high degree of skill and careful attention. This adds to the final manufacturing cost, and, hence, increases the final cost to the consumer. Final product consistency is difficult to maintain.

[0021] Quality control also has become an issue with current spline techniques. Specifically, installers have learned ways to make their jobs easier, to the detriment of quality control. This is particularly true when using PVC spline.

[0022] There are other drawbacks associated with conventional spline techniques. In particular, the use of a separate fastening device, such as a spline, requires separate inventory control and associated costs. Screen manufacturers prefer to minimize inventory. Therefore, it is desirable to eliminate the spline as a separate item. Also, the need to have a strong interference fit in securing the spline necessitates stiff walls on the spline groove. Further, the spline technology makes the design of automatic assembly equipment extremely complex.

[0023] For the foregoing reasons, a need has arisen to provide a screen and frame assembly that eliminates the requirement of a spline. An additional need has arisen to manufacture screen products more easily.

[0024] Some attempts have been made in the art to provide screen and frame assemblies without a traditional spline.

For example, in U.S. Patent No. 3,255,810, a continuous strip of fusible material is fused with the screen material and then inserted into the groove in the frame.

[0025] Accordingly, a need has arisen for a screen and frame assembly for windows, doors and the like in which the screen is secured to the frame quickly, with reduced manual labor.

SUMMARY OF THE INVENTION

[0026] One aspect of the invention is a method and apparatus for securing ventilation cloth to a screen frame. A screen frame is oriented in an approximately vertical position. The screen frame has a plurality of segments. Each segment has a mounting surface on a face thereof. At least one of said segments has adhesive on the mounting surface thereof. A ventilation cloth is hung across the mounting surface of said one segment. The adhesive in said one of the segments is melted. The ventilation cloth is inserted in the adhesive across a length of said one of the segments.

[0027] Another aspect of the invention is a method and apparatus for securing a ventilation cloth to a screen bar segment. A screen bar segment is provided having a mounting surface on a face thereof. The segment has adhesive on the mounting surface. The ventilation cloth is spread across the mounting surface of the screen bar segment. The adhesive is melted. The ventilation cloth is inserted into the adhesive with an elongated insertion member substantially across a length of the screen bar segment simultaneously.

[0028] Still another aspect of the invention is a ventilation cloth insertion apparatus. A fixture clamps a screen frame. The screen frame has a plurality of segments. Each segment has a mounting surface on a face thereof. At least one of the segments have adhesive on the mounting surface thereof. The fixture has a plurality of clamping arms. The clamping arms are positionable so that each clamping arm clamps a respective outside edge of a respective one of the plurality of sides of the screen frame while attaching a ventilation cloth to the screen frame. The outer edges of the screen frame are the edges of the segments that are furthest from a center of the screen frame. Each of the plurality of clamping arms is positioned at a common height with respect to a plane in which the ventilation cloth is positioned. A heater melts the adhesive in the one segment. At least one insertion device inserts a ventilation cloth in the adhesive substantially across a length of said one of the segments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. 1 is a top plan view showing a station including two frame assembly machines according to the present invention.

[0030] FIG. 2 is a side elevation view of one of the machines of FIG. 1, taken along section line 2-2 of FIG. 1.

[0031] FIG. 3 is a side elevation view of the machine of FIG. 2, in a position for heating the adhesive in the frame bar segment.

[0032] FIG. 4 is a side elevation view of the machine of FIG. 2, in a position for inserting the screen and cooling the adhesive in the frame bar segment.

[0033] FIG. 5 is an enlarged, partial cutaway perspective view (with the insulation partially removed) of the nozzle section of the machine shown in FIG. 1.

[0034] FIG. 6 is an isometric view of a first exemplary screen bar segment suitable for assembly in the machine shown in FIG. 1.

[0035] FIG. 7 is an isometric view of the screen bar segment of FIG. 6, with a portion of screen material attached thereto.

[0036] FIG. 8 is an isometric view of a second exemplary screen bar segment suitable for assembly in the machine shown in FIG. 1.

[0037] FIG. 9 is an isometric view of the screen bar segment of FIG. 8, with a portion of screen material attached thereto.

[0038] FIG. 10 is an enlarged view of a portion of the screen assembly shown in FIG. 1.

[0039] FIG. 11 is a cross sectional view of the screen bar segment shown in FIG. 10, taken along section line 11-11 of FIG. 10.

[0040] FIGS. 12A-12C show another exemplary apparatus for automatic insertion of screen cloth into screen frames, wherein the frame is held in a vertical position during insertion.

[0041] FIG. 13 shows an alternate insertion device suitable for use in any of the insertion apparatus described herein.

[0042] FIG. 14A is a plan view of the clamping and insertion apparatus of FIG. 12A, with the arms positioned for clamping a large screen frame.

[0043] FIG. 14B is a plan view of the apparatus of FIG. 14A, with the arms configured for clamping a small screen frame.

[0044] FIG. 15 is a side elevation view of the apparatus shown in FIG. 14A.

[0045] FIG. 16 is a bottom elevation view of the apparatus shown in FIG. 14A.

[0046] FIGS. 17-20 are detailed elevation views of the clamping and insertion devices of FIGS. 15 and 16.
[0047] FIG. 21 is an elevation view of a variation of the apparatus shown in FIG. 12A.
[0048] FIG. 22 is an isometric view of one of the carts shown in FIG. 21.
[0049] FIG. 23 is a right side elevation view of the oven shown in FIG. 21.
[0050] FIG. 24 is an enlarged detail of FIG. 23.
[0051] FIG. 25 is a top partial plan view of the apparatus of FIG. 21.
[0052] FIG. 26 is an enlarged detail of FIG. 25.
[0053] FIG. 27 shows the "folding finger' of FIG. 26 in an alternate position.
[0054] FIG. 28 is a rear elevation view of the apparatus of FIG. 14A, showing screen cloth feeding apparatus.
[0055] FIG. 29 is a side elevation view of the screen cloth feeding apparatus of FIG. 28.

DETAILED DESCRIPTION

[0056] The invention includes a method and apparatus for securing a screen 34 to a frame 30, or to a screen bar segment 30a of the frame 30. The invention also includes a frame and screen assembly formed by the method, and a screen bar stock used in the assembly.
[0057] As shown in FIG. 1, the exemplary frame 30 includes a plurality of screen bar segments 30a-30d. Each screen bar segment 30a-30d has a mounting surface 32a which may be a bottom of a groove or tensioning step 32 or 32' (best seen in FIGS. 6-11) on a face of the frame 30. The frame 30 may have a flat face, and the mounting surface may be a portion of the flat surface (not shown), but a groove 32 or tensioning step 32' is preferred, because it enhances removal of slack in the screen upon insertion of the pins. The tensioning step 32' has a bottom 32a' and at least one side 32b' (shown in FIG. 9). Essentially, a groove 32 is a tensioning step that further includes a second side 32c (shown in FIG. 7).
[0058] These structures and their equivalents are collectively referred to as a "mounting surface" or "tensioning step" herein, for ease of discussion. A mounting surface may be flat or may include a tensioning step. It will be understood that, as used herein the term "tensioning step" encompasses both a tensioning step that is part of a groove, and a step that is not part of a groove. This tensioning step is described in more detail below.
[0059] The screen bar segment 30a has adhesive 36 at the bottom 32a or side 32b of the tensioning step 32. The adhesive 36 may be pre-installed in each screen bar segment 30a-30d before the screen bar segments 30a-30d are assembled to form the frame 30.
[0060] The screen 34 is spread across the frame 30, so that the screen 34 extends over the mounting surface (tensioning step 32) of each screen bar segment 30a-30d (FIG. 10). The screen 34 is secured to the face of the frame 30 with an adhesive 36 at a plurality of positions 37 across a length of the tensioning step 32 of at least one of the screen bar segments 30a-30d.
[0061] Preferably, forced convection with a heated gas having a temperature above the melting point of the adhesive is used to heat the adhesive. For example, the heated gas may be air heated to about 175 C, blown directly onto the adhesive 36 (as shown in FIG. 3) to melt the adhesive. The screen 34 is inserted with an inserting apparatus 52, which may include a plurality of pins 54. Pins 54 embed or suspend the screen 34 in the adhesive 36 intermittently across a length of the screen bar segment 30a, until portions of the screen beneath the pins 54 are inserted in and possibly contact the bottom 32a of the mounting surface (as shown in FIG. 11). The pins 54 of the inserting apparatus 52 contact the adhesive 36 during the inserting step. Natural or forced convection may be used in combination with conduction to cool the adhesive 36. If convection is used, a cool gas having a temperature below the melting temperature of the adhesive 36 is provided. The cool gas may be ambient temperature air, and is blown onto the adhesive 36, or onto the frame, near the adhesive. Preferably, the plurality of pins are removed after allowing the adhesive to cool below the melting point of the adhesive.
[0062] The adhesive may be a hot melt adhesive or a thermoplastic resin having a heat resistance temperature of at least about 35°C, preferably between about 100°C and about 130°C, and a viscosity that is preferably below 5400 poise at about 200°C. For example, the adhesive may be a hot melt adhesive such as polyester, polyamide, polyolefin, polypropylene, polyurethane, butyl or ethylene vinyl acetate based adhesives.
[0063] Referring again to FIGS. 1-5, the apparatus 100 for securing the screen 34 to a screen bar segment 30a includes a support surface 101 that holds the screen bar segment. One or more pre-loading blocks 40 (FIGS. 1-5) are provided to hold a pre-bowed frame 30 against the support surface 101, so that the frame 30 is distorted to a desired camber while the screen 34 is secured. The frame 30 may be held substantially straight, or may be given a reverse camber while attaching the screen, if desired. Preferably, the apparatus 100 includes a plurality of pre-loading blocks 40 arranged outside of the frame to engage all of the screen bar segments 30a-30d of the frame 30 simultaneously. A heat source applies heat directly to the adhesive 36 to melt the adhesive. The heat source may include a plurality of nozzles 58 (shown in FIGS. 2 and 5) that direct a heated gas onto the adhesive 36. The nozzles 58 may be located on a movable body 50. The source of the heated gas may include a hot air plenum 60. In the exemplary embodiment,

the plenum 60 may be located on the movable body 50.

[0064] According to an aspect of the invention, the pre-loading blocks 40 may be positioned outside of the frame 30, without using any stop-blocks inside the frame. The frame 30 may be deformed inward elastically (hourglassed) slightly, so that when the frame is removed from the pre-loading blocks 40, the frame returns to a substantially straight configuration, with sufficient movement to remove wrinkles from the screen material 34. (The screen material 34 has a high modulus of elasticity (Young's modulus) relative to the frame members, so that the frame members are held straight by the screen material. A pair of inside (backstop) blocks may be used to limit the amount of movement when the frame is pre-loaded by the pre-loading blocks 40. The amount of this pre-bow or pre-tensioning is sufficiently small so that, when the frame 30 is released from the pre-loading blocks 40, the screen material 34 is substantially wrinkle-free, but has a sufficiently small amount of tension so as not to overly distort the screen bar.

[0065] . The plurality of pins 54 (best seen in FIG. 5) are located on the movable body 50, proximate to the nozzles 58. The plurality of pins 54 may be arranged in a straight line segment. An actuator 84 raises and lowers the body 50 (or the table) so that the pins 54 simultaneously push the screen 34 into the adhesive 36. The pins 54 are capable of being actuated to embed the screen 34 in the adhesive 36. A release coating (e.g., tetrafluoroethylene ("TEFLON®") or silicone) may be applied to the plurality of pins 54 before inserting the screen 34 with the pins 54. The plurality of pins 54 may be spring loaded with springs 56 to accommodate corners. Successive pins 54 may be spaced apart from each other by a distance δ (FIG. 5) of between about 0.6 centimeters (cm) and about 2.5 cm. Preferably, the distance δ between pins is about 1.25 cm.

[0066] As shown in FIG. 4, the nozzles 58 may also be configured to direct a cool gas directly onto the adhesive 36 when the nozzles 58 are connected to the source of the cool gas. The source of the cool gas may be plenum 70 and may contain ambient air. In the example shown, the nozzles 58 are connectable to either the source of heated gas (hot air plenum 60) or a source of a cool gas (cold air plenum 70).

[0067] The pins 54 may have a diameter P (FIG. 5) that is less than a width W (FIG. 10) of the groove 32 of the screen bar segment 30a by between about 0.05 centimeter and about 0.1 centimeter. For example, the tensioning step may be a groove 32 having a width W of about 0.35 centimeter. A preferred set of pins 54 corresponding to this width have a diameter between about 0.15 centimeter and about 0.34 centimeter, preferably between about 0.25 centimeter and about 0.3 centimeter.

[0068] The pins 54 may be arranged to simultaneously insert the fabric into the adhesive on any non-zero number of sides of the frame. Preferably, the fabric is attached to two of the sides at a time. As shown in FIG. 5, in an exemplary embodiment of the apparatus, the plurality of pins 54 include a row and a column of pins aligned in an angle-shaped configuration, for inserting the screen 34 into the adhesive 36 on two screen bar segments 30a and 30b of the frame 30, simultaneously. The angle may be a right angle as shown in FIG. 5, or another angle for a non-rectangular window. Once the screen 34 is attached to two adjacent sides, the frame is rotated by 180 degrees, and the heating, inserting and cooling steps are repeated to insert the screen 34 into the tensioning steps 32 on a third screen bar segment 30c and a fourth screen bar segment 30d of the frame 30 simultaneously.

[0069] FIG. 10 is a top plan view of the screen bar segment 30a and screen material 34 shown in FIG. 7. In FIG. 10, the segment of screen bar 30a includes a tensioning step provided by the bottom 32a and one side 32b of a groove 32. Adhesive 36 is applied along the base 32a of the tensioning step, in the groove 32 of the screen bar 30a. Therefore, as shown in Figure 10, the adhesive is secured to the screen bar 30a at the base 32a of the groove 32. Also shown in FIG. 10 are a plurality of indentations 37 formed in the adhesive 36 by the insertion pins 54, while embedding the screen material 34 into the adhesive.

[0070] FIG. 11 is a cross sectional view taken along section line 11-11 of FIG. 10. FIG. 11 is not to scale; vertical dimensions are exaggerated to show features of the exemplary assembly. In particular, the screen material 34 may be pushed substantially all of the way to the bottom 32a of the groove 32 by pins 54, forming indentations or openings 37 in the adhesive bead 36 or film, so that the screen substantially contacts the bottom 32a (i.e., not more than a microscopically thin film is interposed between the screen material and the bottom of the groove beneath the indentations.) In between the indentations 37, the screen material 34 is intermittently suspended slightly above a thin layer of adhesive. Thus, the screen material 34 acts to strengthen and reinforce the adhesive 36 in the regions between the indentations 37. The resulting structure is very strong.

[0071] Optionally, the mounting surface 32a of the tensioning step 32 may have a plurality of features 38. The features 38 may be dimples, indentations, holes, slots, striations, or the like. The features 38 are intended to provide a better mechanical bonding surface for the adhesive 36.

[0072] Figure 8 shows a cross-sectional view of a segment of a second type of screen bar 30a' for use in forming a screen and frame assembly in which screen can be adhesively secured to the screen bar. Figure 8 shows that the segment of screen bar 30a' includes a step, lip or wall (hereafter, called a "step") 32' along one side thereof. Adhesive 36' applied along the base of the step 32' of the screen bar 30a'. In this embodiment, since the base of the step 32' has a relatively sharp angle, the adhesive may be applied against the base of the step 32'. Therefore, as shown in Figure 8, the adhesive 36' is secured to the screen bar 30a' along and adjacent to the step 32'.

[0073] In the embodiments shown in Figure 6 or 8, a tensioning step can be provided by a conventional spline groove or the like, or by a step, lip, or wall, for example, as desired. A groove (FIGS. 6, 7, 10 and 11) is preferred over a step (FIGS. 8 and 9), lip or wall that is not a groove, because the groove allows the homeowner to install a replacement spline to replace the screen, if necessary, and may be more aesthetically pleasing (The adhesive and the edge of the screen can be hidden from view.) A groove 32 also protects the adhesive bond area from weather and ultraviolet radiation from the sun, to some degree. Also, if a groove is not used, greater pre-tensioning of the screen material may be necessary to achieve tension in the screen fabric 34.

[0074] Systems according to the present invention use adhesive 36 in the groove 32 or tensioning step of the screen bar 30a (or at the bottom of a tensioning step 32', shown in FIGS. 8 and 9) to secure the screen 34 to the screen bar 30a. The present invention solves problems associated with automated installation of screen material 34 on a frame 30. It is a tremendous improvement over manual techniques for attaching a frame using adhesives, and over the current spline technology for at least the following reasons:

[0075] The invention eliminates the need for manually inserting the screen in the frame. This elimination results in:

[0076] No repetitive strain injury -- specifically, a worker is not likely to suffer carpal tunnel syndrome as a result of practicing an assembly technique according to the invention.

[0077] Much less effort (physical strength) is required to install screen material using the invention. There is less difficulty and manual work to manufacture screen assemblies.

[0078] Little or no skill is required to operate the assembly equipment.

[0079] Screen-to-frame retention (bond strength) fabricated by a method according to the invention is three to four times stronger than bonds fabricated using spline technology. Frame and screen assemblies fabricated using apparatus and methods according to the present invention consistently exceed the current standards for pull out strength, whereas spline technology marginally meets these standards.

[0080] The strength of the fastening is not dependent upon the gauge of the screen bar metal (as is the case with spline technology), thus allowing reduced metal gauge without loss of retention strength performance

Reduced part cost

[0081] The invention provides a two to three-fold increase in assembly throughput, reducing overall cost significantly.

[0082] An apparatus according to the invention can provide low cost, using simple, low-tech machinery. It is far simpler and far better than any automated screen assembly machine currently available commercially.

[0083] Can use existing screen bar profiles, connectors, fastening hardware..

[0084] A frame-screen assembly fabricated according to the invention still allows screen replacement using traditional spline technology by the homeowner.

[0085] Improved consistency of tensioning over manual methods and control of quality independent of the skill of the operator.

[0086] The pins 54 are used both to insert the screen cloth 34 and remove the slack from the cloth. Essentially, the action of pushing the screen cloth 34 past the tensioning step 32, (which is preferably a groove), pulls the cloth 34 taut and pulls out small wrinkles. The taut screen 34 thus holds the pre-bowed frame members 30a-30d straight upon removing the assembly 30 from the pre-loading blocks 40 upon cycle completion. In effect, both the insertion of the pins 54 over the tensioning step 32 and the pre-loading of the frame 30 contribute to consistently setting the desired tension. Thus, it is believed to be most preferred to use both means together. However, tensioning may be achieved by either method, if used alone.

[0087] The insertion pins are large enough to push the open mesh screen cloth 34 into the molten adhesive 36 without passing through the mesh and missing the strands. If the tensioning step 32 is in a groove, the pins 54 must be sized to fit into the groove. The exemplary pins 54 have an axis of rotational symmetry; they are generally approximately cylindrical in shape. In experiments conducted by the inventor, the preferred pin diameter was greater than 0.15 cm (.060") and smaller than 0.34 cm (0. 135") to work effectively with common fiberglass window screen and a screen bar groove of 0. 140". The most preferred diameter observed was 0.25 cm (.100") to 0.3 cm (0.120"). Rectangular shaped pins also appear to function well. Rectangular pins may have a cross section with a larger dimension of about 0.3 cm (0.12") to 1.27 cm (0.5"), big enough so that the pins 54 do not enter the holes in the screen material 34 during insertion. A cross-section of 0.6 cm to 1.27 cm is preferred. One of ordinary skill in the art can readily provide alternate pin cross-sections without any undue experimentation. The larger dimension of the pins may be nearly as wide as the center-to-center spacing between successive pins.

[0088] The mechanism of insertion using pins 54 is different from the spline insertion mechanism in the prior art. The pins 54 push the screen material 34 into the adhesive substantially without any friction between the screen and the mounting surface. The screen is held in place by the adhesive, not by friction. Because this method does not rely on friction between the screen material and the mounting surface, it is possible to use thinner screen bar material than could be used with conventional spline methods. In contrast, the spline technique relies on friction to hold the screen to the frame; a heavy frame material is needed to absorb the insertion force.

[0089] The preferred spacing of the pins is between .63 cm (0.25 inch) to 2.54 cm (1.0 inch) to achieve a practical design. Pins spaced further apart than 2.54 cm are not as effective at pushing the screen 34 in the molten adhesive 36 between the pins. Pins closer together than .63 cm do not improve the insertion and only add cost. The most preferred spacing is approximately 1.27 cm.

[0090] It is important for the pins 54 to extract cleanly from the adhesive 36 (after it has solidified) without undue forces and without strings of adhesive forming as the pins are extracted. Waiting until the adhesive 36 has fully solidified (forced air cooling helps to reduce the cooling time) avoids formation of strings in the adhesive upon extracting the pins 54 from the adhesive 36. Preferably, the pins 54 are smooth (preferably polished), or coated with a release coating such as tetrafluouroethylene (TFE) or the like, to prevent the adhesive 36 from bonding to the pins 54. Exemplary pin materials include aluminum, brass and stainless steel. Stainless steel offer the best durability, corrosion resistance and surface qualities for extraction and is thus believed to be the preferred material. Other materials such as ceramic or high temperature plastic may also be used. Further, pins formed of chrome (or plated with chrome) or TFE are also contemplated. A beryllium material may be preferred for the pins. Beryllium offers high strength and wear resistance and high thermal conductivity for rapid cooling of the adhesive.

[0091] Spring loaded pins 54 may travel approximately the depth of the groove 32 and allow the screen 34 to be assembled without interference by the pins 54 at the corner key of the frame 30 being assembled. The pins over the corner are held up so as to not trap screen cloth between the pin and the comer key. If this trapping should occur, the screen cloth does not flow fully into the groove in the neighborhood of the corner. A poorly bonded comer area results. Essentially, the pins 54 are pushed up using a corner shield device, compressing the springs 56, at the corners of the frame 30. Thus, it is unnecessary to remove pins 54 to accommodate different sized screen frames 30. . In the exemplary embodiment, the springs are intended to be compressed only when there is interference at the corners. Along the sides, the remaining pins inserting the screen typically do not compress their respective springs.

VERTICAL ASSEMBLY APPARATUS

[0092] FIGS. 12A-12C show another exemplary apparatus 3100 for fabricating screen assemblies 3101 according to the present invention. The ventilation cloth insertion apparatus 3100 comprises a fixture 3102 that orients a screen frame 3130a-3130d in an approximately vertical position, as best seen in the side elevation view of FIG. 15. As shown in FIG. 15, the slope 3390 of the exemplary machine is about 5°. Preferably, the angle 3390 is between 5 and 10 degrees or slightly less.

[0093] Preferably, the slope is nearly vertical. The more vertical the machine is, the less likely that the screen cloth 34 will become caught on the frame 30 or a portion of the apparatus 3102 while the cloth is being draped down into position for insertion into the screen cloth. The cloth 34 passes down through a gap 3382 (FIG. 15) between the frame 30 and the arms 3306-3309 (FIG. 14A) on which the insertion device is mounted. Preferably, the cloth can be draped down into position for insertion in the frame 30 without the cloth touching the frame or the machine while the cloth is moving into position. The closer the apparatus is to vertical, the less floor space is required. Also, the more vertical the apparatus, the easier the cloth handling becomes. And the more vertical the machine is, the easier it is to transfer the frame from the oven to the insertion station 3102. A small angle allows the frame to be supported from behind, for example by backplate 3302. Similarly, with a small angle, the frame can be supported by rails while being transported. A perfectly vertical frame would require more support from the transports 4010 and 4040 (FIGS. 22 and 26) that move the frames.

[0094] Alternatively, a perfectly vertical frame could be used, and the conveyor may have a hook or extension to prevent the frame from falling over. If the frame is stabilized, a completely vertical screen provides the best screen cloth drape. An angle between 0 degrees and about 30 degrees may be used, so long at the angle is sufficiently small so that there is no significant interference with the ability to drape the cloth 34 down over the frame.

[0095] The apparatus 3100 also provides for automated feeding of the frames 30 through the oven to the insertion apparatus, and automated feed of the screen cloth 34 to a position for insertion in the screen frames 30.

[0096] The apparatus includes an insertion fixture 3102 and a heater 3103, which may be a separate oven 3103, as shown in FIG. 12A, or an integrated heating mechanism on the insertion fixture 3102. Preferably, a conveyor 3104 delivers the screen frames 3130d to the oven 3103, conveys one or more frames being heated through the oven, and delivers heated frames 3130a to the insertion apparatus 3102. The conveyor 3104 is optional. In configurations having the heater (not shown) mounted on the insertion fixture, the conveyor may be significantly shorter (e.g., to accommodate only one frame), or may be omitted.

[0097] The apparatus 3100 can accommodate a variety of screen frames that may have different sizes. For example, a completed frame-screen assembly 3101 exiting the apparatus (on the left) has a size that is much smaller than the size of the frame 3130a entering the screen insertion apparatus 3102. The mechanisms for accommodating different screen sizes are explained in detail below. Each screen frame 3130a-3130d has a plurality of segments. Each segment has a mounting surface on a face thereof. At least one (or, preferably, each) of the segments has adhesive on the mounting surface thereof.

[0098] A hanger hangs a ventilation cloth across the mounting surface of the at least one segment having the mounting surface. Preferably, the hanger hangs the ventilation cloth so that the cloth hangs over each of the mounting surfaces simultaneously.

[0099] The heater melts the adhesive in said one of the segments. As noted above, this may be accomplished using an oven 3103, a hot air blower, electric heaters or other heating mechanism (not shown) on the insertion apparatus 3102.

[0100] At least one insertion device inserts the ventilation cloth in the adhesive substantially across a length of said one of the segments. A variety of insertion devices may be used. For example, the insertion device may include a plurality of pins 2222 (shown in FIG. 22), or an elongated insertion blade or band 3200 as shown in FIG. 13. The insertion blade or band 3200 may extend for all or substantially all of the length of the screen bar segment 30a-30d, so that a respective single blade or band performs the insertion of screen cloth 34 for substantially the whole length of each respective side of the frame, excluding the corner keys.

[0101] FIGS. 14A-16 are detailed views of the insertion apparatus 3102. The assembly 3302 has four clamping arms, 3306-3309. The clamping arms 3306-3309 are positionable so that each clamping arm clamps a respective outside edge of a respective one of the plurality of sides of the screen frame 30 while attaching a ventilation cloth 34 to the screen frame. (The outer edges of the screen frame 30 are the edges of each frame segment 30a-30d that are furthest from a center of the screen frame.) The four arms 3306-3309 are coplanar. That is, each of the plurality of clamping arms3306-3309 is positioned at a common height with respect to a plane in which the ventilation cloth 34 is positioned.

[0102] Referring now to FIG. 14A, in the exemplary fixture 3102, three of the clamping arms 3307-3309 are movable with respect to the remaining arm 3306. Arm 3307 is slidably mounted to translate in the left-right direction in FIG. 14. One end of arm 3307 slides along stationary arm 3306 in a pair of yolks 3323 and 3324. Each yolk 3323 and 3324 is slidably mounted on a respective rail 3318 and 3316.

[0103] Arm 3308 moves both vertically and horizontally. The right end of arm 3308 moves from left to right and right to left along with arm 3307. In addition, arm 3308 moves up and down with respect to arm 3307.

[0104] Arm 3309 only moves up and down, in a direction parallel to its length. Thus, arm 3309 always is positioned at the left end of arm 3306.

[0105] As a result, when the apparatus is reconfigured to accommodate a smaller frame, arms 3307-3309 move as shown in FIG. 14B. Arm 3307 moves leftward to clamp the rightmost edge of frame segment 30b. Arm 3308 moves downward to clamp the topmost edge of frame segment 30c, and moves leftward by the same distance as arm 3307, so that the right end of arm 3308 meets arm 3307. Arm 3309 moves downward by the same distance as arm 3308, so that the top end of arm 3309 meets arm 3308. Arm 3306 continues to clamp the bottommost edge of frame member 30a, and arm 3309 continues to clamp the leftmost edge of frame member 30d.

[0106] The basic orientation of the apparatus 3103 is vertical, with a slight incline to allow for the frame members 30a-30d to be supported by the back plate, 3302, so as the frame 30 comes in from the right hand side of the FIG. 14A, the frame comes in under arm assembly 3307. Clamp Arm assembly 3307 lifts (in a direction away from the backplate 3302 shown in FIG. 15) and allows the frame to travel along the back plate 3302. As gravity pulls the frame down to Arm 3306 the frame 30 rests along the fixed clamp plate 3373 as shown on FIG. 18. There is a slot 3303 that is shown on the back plate 3302.

[0107] Depending on if it's a new size or the same size as the one that was just finished, the arms 3307-3309 may either open fully in the case of a new screen size to a home position as shown in figure 33A, or it will just open slightly, just enough to be ready for the next frame 30 without opening up more than it needs to.

[0108] Optionally, a bar code reader or keypad may be used to scan or type in an indication of the frame size. Linear encoders attached to the rodless cylinders that move the arms 3307-3309 (or other measuring means) may be used provide a means for determining the location of the arms, and the current opening size at any time. By identifying the destination size to the system, and measuring the current size, it is possible to avoid opening the arms fully to their home positions (shown in FIG. 14A), even when changing frame sizes.

[0109] The next frame is then pushed into the machine 3102 and the clamp gate opens allowing the frame 30 to pass under Arm 3307. Arm 3309 of the gate will have already shut and the little conveyor through that slot 3382 slides the screen frame assembly over to the gate of clamp Arm 3309. It will be a hard stop. An air cylinder pushes the gate up to its final position. Arm 3307 moves over to the left just until it touches the screen bar 30b, thus clamping and/or straightening out the pre-bow from screen bar 30b. The air cylinder 3329 at the bottom of the apparatus actuate Arm 3307 and clamps the vertical members 30b and 30d of the screen frame. Arm 3308 also comes down and clamps or touches the top frame member 30c and clamps the two (optionally pre-bowed) horizontal frame members 30a and 30c straight, thus clamping and straightening the frame 30 on all four sides. Arm 3308 is actuated by an air cylinder 3330 along the left side.

[0110] Although the exemplary system moves the frame 30 into place in the insertion apparatus 3102 by inserting the frame through the gap 3382 (FIG. 15) on the side of the apparatus, alternative embodiments are contemplated in which the frame is loaded from the front. To front-load the frame into the apparatus, the arms 3307-3309 are either open to their home positions (FIG. 14A), or if the frame size is identified to the system (e.g., via bar code or keypad entry), the arms can be opened by a small amount beyond the size of the frame, the frame moved into position, and the arms repositioned to clamp the frame.

[0111] Loading the frame 30 into the insertion apparatus 3102 from the right side is only an example. One of ordinary skill can readily configure the apparatus so that it is possible to load the frames from above or below, or from left or right.

[0112] Note that the movement of the arms 3307-3309, as described above, may either be sequential or simultaneous.

[0113] The frame remains clamped between arms 3306-3309 while the ventilation cloth 34 is being inserted in the screen bar grooves. The cloth 34 is inserted into the groove, and then pushed out to the left under arm 3309. After that, the clamp gate assembly lifts up (away from the backplate 3302, in a direction normal to the loaded frame) and allows the finished screen frame assembly to pass through.

[0114] Understanding of the details of FIGS. 14A-20 will be facilitated by the brief parts list immediately following this paragraph. This is only a partial list; conventional fasteners, finishing coatings and the like are omitted, for brevity.

[0115] Parts list for FIGS. 14A-16: General Arrangement of arm assemblies

3301 SUPPORT FRAME
3302 BACK PLATE
3303 LOAD/UNLOAD SLOT
3304 SMALL SCREEN (IN POSITION)
3305 LARGEST SCREEN (IN POSITION)
3306 LOWER HORIZONTAL ARM ASSEMBLY (ARM 1)
3307 RIGHT AND VERTICAL ARM ASSEMBLY (ARM 2)
3308 UPPER HORIZONTAL ARM ASSEMBLY (ARM 3)
3309 LEFT HAND VERTICAL ARM ASSEMBLY (ARM 4)
3310 SUPPORT 1
3311 SUPPORT 2
3312 SUPPORT 3
3313 SUPPORT 4
3314 RIGHT HAND VERTICAL GUIDE RAIL
3315 LEFT HAND VERTICAL GUIDE RAIL
3316 UPPER HORIZONTAL (STATIONARY) GUIDE RAIL
3317 ARM 3 HORIZONTAL GUIDE RAIL
3318 ARM 1 RAIL
3319 ARM 2 RAIL
3320 ARM 3 RAIL
3321 ARM 4 RAIL
3322 ARM 1 CORNER YOKE
3323 ARM 2A CORNER YOKE
3324 ARM 2B CORNER YOKE
3325 ARM 3A CORNER YOKE
3326 ARM 3B CORNER YOKE
3327 ARM 4 CORNER YOKE
3328 YOKE LINEAR BEARING BLOCK (TYPICAL)
3329 HORIZONTAL RODLESS CYLINDER
3330 VERTICAL RODLESS CYLINDER
3331 ARM 2 STABILATION CABLE ASSEMBLY
3332 ARM 3 STABILIZATION CABLE ASSEMBLY
3333 ARM 2 PULLEY #1
3334 ARM 2 PULLEY #2
3335 ARM 2 PULLEY #3
3336 ARM 2 PULLEY #4
3337 ARM 2 PULLEY #5
3338 ARM 2 PULLEY #6
3339 ARM 3 PULLEY #1
3340 ARM 3 PULLEY #2
3341 ARM 3 PULLEY #3

3342 ARM 3 PULLEY #4
3343 ARM 3 PULLEY #5
3344 ARM 4 PULLEY #6
3345 ARM 2 LOWER CABLE CLAMP/RODLESS CYLINDER ATTACHMENT
3346 ARM 2 UPPER CABLE CLAMP
3347 ARM 3 LEFT HAND CABLE CLAMP/RODLESS CYLINDER ATTACHMENT
3348 ARM 3 RIGHT HAND CABLE CLAMP
3349 HORIZONTAL LINEAR ENCODER
3350 VERTICAL LINEAR ENCODER
3351 PRESS CYLINDER SUBASSEMBLY
3354 ARM MEMBER
3375 CLAMP BAR SUPPORT COLUMN

[0116] Parts list, FIG. 17 TYPICAL PRESS CYLINDER ASSEMBLY (ONE AT EACH END OF EACH ARM ASS'Y)

3351 PRESS CYLINDER SUBASSEMBLY
3352 PRESS CYLINDER
3353 ADAPTER BLOCK
3354 PRESS ARM MEMBER
3355 CARRIAGE
3356 LINEAR BEARING BLOCKS
3357 LINEAR RAIL
3358 CYLINDER SUPPORT ARMS (2 PER CYLINDER)
3359 MAIN SUPPORT PLATE
3360 SUPPORT ARM MEMBER
3361 PRESS TRAVEL STOP (ADJUSTABLE)
3362 PIN ASSEMBLY
3363 PIN (TYPICAL EVERY 5/8 INCH)
3364 PIN SPRING
3365 PIN BLOCK
3366 PIN BLOCK MOUNT
3367 COOLING AIR MANIFOLD
3368 AIR DELIVERY PORTING
3369 AIR NOZZLE
3370 SUPPLIMENTAL AIR MANIFOLD
3371 SUPPLIMENTAL AIR NOZZLE

[0117] Parts List, FIG. 18 STATIONARY CLAMP PLATE ASSEMBLY

3372 SCREEN BAR
3373 REPLACEABLE CLAMP BAR
3374 CLAMP BAR MOUNT
3375 CLAMP BAR SUPPORT COLUMN (2 PER ARM)
3376 CLAMP BAR HEIGHT FINE ADJUST MECHANISM

[0118] Parts List, FIG. 19 MOVING (GATE) CLAMP PLATE ASSEMBLY

3377 MOVING CLAMP BAR SUPPORT COLUMN (2 PER ARM)
3378 MOVING CLAMP BAR SUPPORT COLUMN RAIL
3379 MOVING CLAMP BAR SUPPORT COLUMN BEARING BLOCK
3380 MOVING CLAMP CYLINDER
3381 CORNER SHIELDS
3382 SPACE

[0119] Arm 3307 of the screen clamp assembly 3102 is a movable assembly that moves up and down (i.e., normal to the plane of the loaded frame 30). It's actuated by 2 different cylinders as shown on FIG. 19, and this allows the screen to be loaded and slid along the main plate 3302. All of the Arms 3306-3309 and supporting superstructure, is supported on four posts that are approximately in the 4 comers of the machine so these are Item numbers 3310, 3311, 3312, and 3313. One of these support columns (Item 3312) can be seen in FIG. 15.

[0120] So Arm assembly 3306 includes a rail 3318 and a support arm member 3360. This is a stationary rail member, and at the top of the apparatus is another stationary rail member3316. Arm assembly 3307 slides and includes rail 3319. Assembly 3307 slides to the left and right on rail 3316 at the top and rail 3318 at the bottom. Arm 3307 is connected to each of these with the yolks at the bottom. At the bottom is yolk 3323 which has slide bearing blocks in the bearing rails. At the top arm 3307 is connected with another yolk which 3324. Yolks 3323 and 3324 give Arm 3307 the horizontal action. This horizontal motion is accomplished with an air cylinder 3329 at the bottom of the machine. Cylinder 3329 is a rodless air cylinder that is connected to yolk 3323 via an Arm-3307-lower-cable-clamp/rodless-cylinder attachment 3345. There's also another cable clamp 3346 at the other end of Arm 3307.

[0121] This cable system performs the function of keeping Arm 3307 vertical; i.e., to make it perfectly perpendicular to Arm 3306 and Arm 3308 and parallel to Arm 3309. The cable system ties the top yolk 3324 and the bottom yolks 3323 together, so arm 3307 doesn't have a tendency to tilt or twist. The exemplary mechanism includes cables and pulleys; alternatively, timing belts, or drive shafts with a rack and pinion, a spline shaft assembly, or air cylinders, or one of many different mechanisms could be used.

[0122] In the exemplary system, as the Arm 3307 moves to the left, the cable is fed down to the left and goes, or proceeds around pulley 3333. The cable then travels back inside of Arm support member 3360 which is a hollow tube, and goes back and travels around pulley 3338. From pulley 3338, the cable travels up the machine to pulley 3337. The cable travels around pulley 3337 and ends at the cable clamp 3346 on the right side of the cable clamp. Each end of the cable, is attached to this cable clamp, with a threaded adjustment for fine tuning of the alignment of the Arm 3307.

[0123] When the air cylinder moves to the right then the tension on that cable pulls the top of Arm 3307 to the right. If Arm 3307 moves to the left, then another cable which goes from attachment 3345 in the other direction (which is to the right) and proceeds around pulley 3334. Then the cable goes up to pulley 3335 which takes it inside of the supporting member 3316 and goes around pulley 3336. And from pulley 36 it returns back to the cable clamp 3346 for Arm 3307. When arm 3307 moves to the left, the air cylinder which is down at the bottom pulls the bottom of Arm 3307 to the left and pulls the cable which then pulls the top to the left. These two cables in conjunction with each other keep Arm 3307 perpendicular to Arm 3306 and keep the squareness of the machine.

[0124] In a similar manner, Arm 3308 moves in two directions. It moves horizontally back and forth and also vertically up and down (within a plane parallel to the loaded frame 30). To keep Arm 3308 square in a vertical motion, another Arm 3317 serves as horizontal guide rail for Arm 3308; Arm 3317 is a guide rail which moves only vertically up and down (in a plane parallel to the loaded frame). It does not move horizontally back and forth but it provides the horizontal alignment for Arm 3308. It is supported by a corner yolk 3326 on the right hand side and corner yolk 3326 travels on a vertical rail 3314. Rails 3314 and 3317 are positioned further from the base plate 3302 than the arm assemblies 3306-3309.

[0125] Arm 3308 has a horizontal guide rail 3317 that supports it on the right hand side. On the left hand side it is supported through a corner yolk 3327 which is also the corner yolk for Arm 3309. The corner yolk 3327 travels in a vertical direction up and down a left hand vertical guide rail 3315. Comer yolk 3327 also supports Arm 3309 and allows Arm 3308 to pass underneath the corner yolk so that smaller screen frames can be accommodated.

[0126] Also, the vertical travel is controlled through guide rail 3317. Arm 3308 is supported on each end by the corner yolks 3326 and 3327. On the left side of the machine (in FIG. 14A) is a vertical air cylinder 3330 which is attached to the vertical cable clamp 3347, and this is shown in FIG. 16. The air cylinder 3330 moves this whole mechanism up and down (relative to the backplate 3302, normal to a plane of the loaded frame). A counter weight mechanism is also provided. This air cylinder 3330 may be only strong enough to move the mechanism but is not required to support the weight of the mechanism in a neutral position. Thus, there is a counter weight (not shown) to the system, which just equals the weight of the vertical travelling members.

[0127] The counter weight assembly (not shown) may include a cable attached to corner yolk assembly 3327. The cable passes up the machine, over the top of the machine, and then back down and either attaches to a spring or a counter weight, a physical weight, or an air cylinder that just will counter the weight of the clamping arm assemblies.

[0128] Arm 3308 is clamping the screens so it must remain parallel to Arm 3306 (for a screen frame that is rectangular). A cable arrangement similar to that described above is provided. This cable arrangement starts with cable clamp 3347 on the left side of the machine (FIG. 14A). A cable comes out the bottom of clamp attachment 3347 and proceeds down to pulley 3342. The cable returns up through the inside of the supporting member for guide rail 3315. The cable travels up to pulley 3343 then it travels to the right hand side and joins up with and goes around pulley 3344. The cable then travels down to the cable clamp 3348 on the other end of Arm 3308. This cable provides the tension to hold up the right hand side of Arm 3308 when there's nothing in the system. When the screen is clamped, to keep this right hand of Arm 3308 down, another cable comes out the bottom of cable clamp 3348. The cable comes down around pulley 3339, the cable passes back up around pulley 3340 and travels over to the left to pulley 3341. From pulley 3341 it travels to cable clamp 3347. These two cables in conjunction with each other keep the horizontal guide rail 3317 for Arm 3308 horizontal.

[0129] On the left side of the screen (FIG. 14A) there is a vertical Arm assembly 3309. Arm 3309 is guided vertically on the left hand vertical guide rail 3315. Arm 3309 is connected with yolk 3327 at one end. At the bottom end Arm 3309 is attached with the corner yolk 3322 for Arm 3306. Yolk 3322 holds some bearing blocks on it and allows the Arm 3309 to travel vertically up and down (the up and down directions in FIG. 16, towards or away from the backplate 3302) and maintain a vertical orientation. The vertical member 3315 is attached at the top of the machine to support Arm 3316 via a little corner plate 3313.

[0130] There are stationary rails on the outer periphery of the machine on the right side, supporting stationary supporting Arm 3308 and the top rail which is right at the very top of the machine is supporting Arm 3307, the bearing block for Arm 3307 at the one end and at the other end its at the post end at 3313 supports member 3315. In turn, rail 3315 is supported at the other end. Rail 3315 supports Arms 3308 and 3309 through yolk 3327. Arm 3306 at the bottom of the machine is supported by the support post 3310 at the bottom left corner of the machine 3102.

[0131] Also shown in FIG. 16 is a corner shield 3381. The corner shield 3381 can be pneumatically actuated into, or out of place, to prevent the pins from trapping the screen cloth at the corners, which can result in the cloth fully entering or being inserted into the groove 32 of the screen bar.

[0132] FIGS. 17-20 show details of the clamping / press mechanism. FIG. 17 shows the air manifolds and the pins and a cylinder 3352 that activates the pressing action. FIG. 18 shows the way in which the arrangement of the pins 63 in relationship to the screen bar 30 in relation to the clamping assembly. FIGS. 19 and 20 shows a special case where the clamp plates 3373, 3374 moves up and down under control of cylinder 3380.

[0133] Because the machine 3102 allows for side loading of the screen frames as well as front loading, the screen frames pass through the gap 3382 shown FIG. 15. For the screens to go through the gap, the clamp plates have to move out of the way. The two side clamp plates act as gates as well as the clamp bars, to keep the screen frame 30 in position. The clamping mechanism 3373 and 3374 on Arm 3307 and Arm 3309 can be raised and lowered by an actuating cylinder 3380 (as shown in FIG. 19). By raising the clamping mechanism 3373, 3374 out of the way, the frame can be loaded in from the side. Once the frame 30 is past the arm 3307, the clamping mechanism is lowered again. Arm 3306 and Arm 3308 can be stationary as shown in FIG. 18, and the moving clamp mechanisms on Arm 3307 and Arm 3309 are shown in FIGS. 19 and 20, respectively.

[0134] Optionally, if the frame is to be loaded from the top or bottom, then arms 3306 and 3308 can be configured to be movable up and down (in the direction parallel to the insertion devices 3363), and arms 3307 and 3309 would not require up and down movement (normal to the plane of the loaded frame). To insert the frame from the top or bottom, the clamping mechanisms 3373 and 3374 of arms 3308 and 3309 would be raised away from the backplate 3302, the frame is inserted through the top or bottom, and the arms 3306 and 3308 would return to their normal plane.

[0135] The slot 3303 is in the back plate 3302. Slot 3303 provides a mechanism to push the frames into the machine 3102 and out of the machine. Two rodless air cylinders with little fingers slide the screen frames into the machine and out of the machine. Once the frame 30 is in position, as shown in FIG. 19, the screen cloth is suspended or draped down. Preferably, the screen cloth 34 is automatically fed down to cover the area of the screen frame 30. After the screen cloth 34 is stopped in position, it is draped in that area. The press 3102 closes; the pins 3363 come down and push the screen cloth into the groove 32 in the screen bar 30.

[0136] Figure 36 shows the press assembly 3102 and the cylinder that activates the press. The exemplary gap between the pins 3363 and the groove 32 of the screen bar 30 is about 10 centimeters (4 inches). Other gap sizes may be used. The exemplary gap of 10 centimeters allows enough room to get the screen frame 30 in and out, but is not so far so that excess time is required to close the press. So, just before the screen cloth is in position for the next assembly to be completed, the (previous) finished screen frame from the previous cycle is ejected out of the machine 3102.

[0137] In the example, the outside of the frame 30 is clamped and the pins 3363 are part of the clamping assemblies, as shown in FIGS. 17-20. Because the pins 3363 are physically attached to the clamp Arms 3306-3309 by a fixed distance, the pins are now in location when the frame 30 is clamped as shown in FIGS. 18-20. A modular, replaceable clamp bar 3373 is designed to suit the particular screen bar profile being used (The profile is the distance from the outside edge of the screen bar to the center of the spline groove 32).

[0138] Note that in apparatus 3102 the registration of the frame is performed from the outside of the screen bar as the frame is clamped, to position the pins for insertion. (Other embodiments, not shown, use registration with reference to the inside edges of the screen bar).

[0139] FIG. 21 is an elevation view of an apparatus similar to that of FIG. 12A. The apparatus of FIG. 21 includes a smaller oven 4004 that is capable of holding two frames (one behind the other) simultaneously. FIG. 21 shows the transport mechanism in greater detail.

[0140] At the right side of FIG. 21 a pair of transfer (rodless) cylinders 4020 actuate a pair of carts 4010 and 4011. Each cart 4010 and 4011 holds a respective frame 30. By actuating cylinders 4020, the carts 4010, 4011 are moved from right to left to move the frame into the right end of the oven 4004, and outside the left end of the oven.

[0141] An exemplary cart 4010 is shown in FIG. 22. Cart 4010 has a generally L-shaped bracket 4102, for fitting around a corner of a frame 30. The cart 4010 has a plurality of insulated pads 4104. A spring-loaded finger 4108 rotates into the position shown in FIG. 22 to lock the frame 30 to the cart 4010.

[0142] The insulated pads 4104 avoid hot spots in the frame that might melt the glue. The insulated pads may be sized to provide a light interference fit, but should be sufficiently sized to avoid denting the frames. The three insulated pads 4104 clip the frame 30 while allowing any size screen without touching the corner keys (thus avoiding blemishing the corner keys). The frame can be bigger than the cart 4010.

[0143] In a small frame, the center of gravity of the frame is close to the left clip 4104 in FIG. 22. The frame sits and is supported by the clips 4104 without touching the spring loaded finger 4108. As the screen size increases and the center of gravity of the frame moves away from the cart 4010, the frame 30 tends to lift off of the right clip, and thus the finger 4108 stabilizes the frame by preventing the frame from lifting up out of the cart. The large frame rests against the finger and the bottom of the left clip. The clip 4104 on the vertical member of cart 4010 stabilizes the frame in the vertical orientation, and provides a means to push the frame forward.

[0144] An actuator 4110 may be provided to rotate the finger 4108 out of the way to load the frame onto or off of the cart 4010. Alternatively, the finger can be spring loaded to bias finger 4108 into the position shown, and the finger can be opened manually to insert or remove a frame. Alternatively, the finger can be configured so as to be mechanically triggered to close when a frame is placed in the position shown in FIG. 22. Alternatively, the finger 4108 may be a retractable finger, and may be actuated mechanically or pneumatically, instead of a passive spring-loaded device.

[0145] FIG. 23 is a side elevation view of the oven 4004 shown in FIG. 21, taken viewed along section line 42-42. The oven 4004 has an hot air feed duct 4202 into which the hot air is fed at a temperature between about 150 and about 300 degrees C, depending on the desired cycle time and the type of adhesive used. The hot air is forced up through the oven 4004, and exits through an outlet duct 4203. Air from outlet 4203 is fed through a heater and returned to the inlet duct 4202.

[0146] FIG. 24 is an enlarged detail of FIG. 23. As shown in FIG. 24, cart 4010 may be higher than cart 4011. This difference in the height of the carts 4010, 4011 is optional, and may be used if there is insufficient room for the two rodless cylinders 4020 to be positioned side-by-side at the same height. For example, if a wider oven 4004 is used, then the rodless cylinders 4020 may be placed further apart, and it would not be necessary to locate the carts 4010 at different heights. FIG. 24 also shows a pair of screen frame support rails 4210 and 4211. In the example, rail 4210 is in the same plane as the insertion apparatus 3102.

[0147] Referring again to FIG. 21, the heated frames are pushed out of the oven 4004, and are transferred to the back support frame 4002. A folding finger gate 4040 lets the frame pass through and prevents the frame from traveling backwards. Preferably, the folding finger is a passive device, as described below.

[0148] FIG. 25 shows the hand-off between the oven conveyor and the transfer conveyor. The screen frame 30 is pushed to the left by its respective cart 4010 (or 4011). A pair of guide rollers 4404 bring the frame 30 from an out-of-plane position to an in-plane position (These positions are shown in FIGS. 24 and 25). Alternatively, instead of rollers, a guide bar or plate may be used. When the frame 30 pushes against the folding finger 4040, the finger pivots clockwise about its axis 4048, as shown in FIG. 27. A spring 4042 biases the finger to the position shown in FIGS. 25 and 26. When the frame 30 passes to the left of the folding finger 4040, the spring 4042 pulls the finger back to its rest position, as shown in FIG. 26. When finger 4040 is in this position, the frame 30 cannot move backwards. A block 4044 prevents the spring from pulling the finger 4040 back past its rest position. Finger 4042 is mounted to the carriage 4046 of a rodless cylinder 4402 (shown in FIG. 25). Once the frame 30 is in the position shown in FIG. 26, the rodless cylinder 4402 moves the carriage 4046 (and thus the frame 30) into the clamping apparatus 3102.

[0149] A second folding finger assembly 4050 pushes the finished screen frame assembly out of the insertion apparatus 3102. The operation of the assembly 4050 is the same as described above with reference to assembly 4040.

[0150] FIGS. 28 and 29 show an exemplary automatic screen cloth feed for the insertion apparatus 3102. FIG. 28 is a rear elevation view of the apparatus shown in FIG. 14A. FIG. 29 is a right side elevation view of the apparatus shown in FIG. 28. Details of the insertion apparatus are omitted from both FIGS. 28 and 29 for easier viewing of the cloth feeding apparatus.

[0151] The exemplary apparatus includes five different feeds for feeding any one of five different widths of screen cloth 34 at any given time. This allows rapid switching between screen assembly widths. Although is also possible to use a single cloth feed with the cloth that corresponds to the widest assembly made on the apparatus, using different cloth widths substantially reduces wasted cloth.

[0152] Each width of cloth is fed from a roller 4730. At the top of the assembly, a plurality of nip rollers 4710 and 4711 feed the cloth. Rollers 4710 are beneath each piece of cloth, and rollers 4711 are above each piece of cloth. A plurality of drive units 4720 (which may be reversible quarter horsepower motors) drive the rollers to feed the cloth. There is one lower sensor (such as a photoeye 4750) at the bottom of the clamping assembly 3102. When the cloth 34 is being fed out, the motor 4720 stops when the cloth reaches photoeye 4750.

[0153] Only one of the rolls 4730 of cloth 34 pays out at any given time. When the insertion apparatus is being reconfigured to change to a new size of screen frame, the previously used cloth is retracted, and the next cloth to be used is paid out. To retract the cloth from the last screen frame assembly, the motor 4720 corresponding to that cloth is operated in reverse. A plurality of sensors (such as photoeyes 4740) are positioned, one below each nip roller 4710. When the cloth 34 retracts so that the photoeye for that roll of cloth no longer detects the presence of cloth below roller 4710, then the motor 4720 for that roll of cloth is turned off.

Adhesive

[0154] Adhesive is applied in the groove 32 of the screen bar 30a or against or close to the base of the step 32' of the screen bar 30a'. In either case, the adhesive 36 is applied along the base 32a of the respective tensioning step 32. As is described below, the adhesive 36 may be applied as a film or bead.

[0155] In either the embodiment shown in Figure 6 or that shown in Figure 8, the adhesive 36 is secured to the screen bar 30a along the base 32a of the respective tensioning step 32. The term "secured" or the term "bonded" as used herein is intended to include the generally accepted terms for adhesion of one material to another, i.e., mechanical interlocking, the formation of direct chemical bonds across the interface of the materials and electrostatic attraction, as discussed in Engineered Materials Handbook, Vol. 3, "Fundamentals of Adhesives and Sealants Technology". ASM International Handbook Committee, page 40. By far, the dominating adhesion mechanism, especially in the absence of reactive groups, is the electrostatic attraction of the adhesive to the screen bar as the adherent and vice versa. These are primarily dispersion forces (London forces) and forces arising from the interaction of permanent dipoles. These forces provide much of the attraction between the adhesive and adherent and contribute significantly to the cohesive strength of the adhesive polymer. Mechanical interlocking is assisted by the roughness and porosity of the adherent, in this case, the screen bar. The formation of covalent chemical bonds requires that there be mutually reactive chemical groups tightly bound on the adherent surface and in the adhesive.

[0156] Preferably, the adhesive 36 is applied while the screen bar 30a or 30a' is being made. The screen bar substrate itself may be made from metal, plastic, composites, wood and the like. By way of example, the screen bar 30a or 30a' may be made by either roll-forming or extruding metal (or by extruding plastic) into a segment of screen bar 30a or; 30a' and forming groove 32 (or step 32') along one side of the screen bar segment 30a (or 30a').

[0157] Equivalent methods may be used for other materials. At this time, adhesive 36 or 36' is applied in the groove 32 of the segment of screen bar 30a (or along the base of the step 32' of the segment of screen bar 30a'.) However, if desired, the adhesive 36 may be applied in a separate ("off-line") operation subsequent to the manufacture of the segment of screen bar 30a or 30a'.

[0158] During roll-forming, for example, the adhesive may be applied to the flat strip, before it passes through the rollers of the roll former, or, preferably, at or near the exit end after the screen bar has been shaped. If the adhesive is applied to the flat strip, however, the adhesive must be allowed to cool before roll-forming, which takes time and space, and it is more difficult to position the film or bead of adhesive correctly. In the case of extruded screen bar, the adhesive can only be applied after the screen bar has been formed, or off-line.

[0159] In each of the above cases, adhesive may be applied to the screen bar using a standard hot melt adhesive applicator using a bulk melter and a constant displacement pump or the like. Alternatively, a screw-type extruder may be used for this application. Either a film or a bead of adhesive having a desired thickness can be applied. For both types of applications (bulk melter or extruder), the hot melt adhesive (in bulk, pellet or granular form) is heated above the melting point and pushed through a small orifice (nozzle) to stream into the groove 32 of the screen bar 30a-30d or along the base of the step 32' of the screen bar (or to its final location, if applied onto the flat strip before the strip is roll-formed), which is driven under the nozzle at a constant speed. The molten adhesive is allowed to cool to room temperature, and the finished screen bar with applied adhesive can then be stored. Typically, roll-forming lines run at a speed between 100 and 400 feet per minute and slightly less for aluminum extrusion. Off-line application typically runs at 100 to 300 feet per minute. By way of example, the reapplication of a 0.05" diameter bead of adhesive having a specific gravity of 1.02 (typical for polyamide) will need to be supplied at 8 pounds per hour to meet a 100 feet per minute line speed and 48 pounds per hour for a 300 feet per minute line speed.

[0160] Alternatively, the adhesive may be pre-extruded as a solid ribbon. The cooled solid ribbon of adhesive may be roll-formed into the screen bar during the roll-forming process. Near the end of the roll-forming process, when the screen bar material is close to its final shape, the ribbon of adhesive is introduced, and the material forming the screen bar may be bent around the ribbon of adhesive to retain the adhesive. The solid adhesive may also be pressed into the roll formed bar after the roll-forming is complete. Preferably, any roll-forming lubricants that may be present in the groove or tensioning step are removed before applying the ribbon of adhesive. Although applying the adhesive in a sold, pre-extruded form may add an extra step to the screen bar roll-forming process, it eliminates the need to heat the screen bar above 60 ° Celsius to obtain good adhesion between the screen bar material and the adhesive.

[0161] Preheating the screen bar just prior to application of the adhesive, to between about 40 and about 150°C, greatly improves the adhesion between the adhesive and the screen bar. Flame treatment of the surface of the screen bar also improves this adhesion. Therefore, when applying the adhesive, it is preferable to heat the screen bar at the location of adhesive application. Heating the side of the screen bar that the adhesive contacts significantly lowers the viscosity of the adhesive and allows it to flow easily at the heated interface. This provides a mechanical bond (interlocking) on a microscopic scale, in that the adhesive flows into any minute imperfections in the screen bar, as well as an electrostatic bond. It is preferable to heat the screen bar to a temperature in the range of about 40°C to about 150°C, with about 60°C to about 120°C being preferred and about 60°C to about 100°C being most preferred. A propane flame or like heating element can be used to heat the screen bar in this manner. Corona treating, as is routinely used in the plastic and adhesive industry may also improve bond strength, depending upon the substrate.

[0162] Mechanical bonding also can be effected by perforating the bottom 32a of the groove 32 or the bottom 32a' of the screen bar 30a' adjacent to the step or lip 32b. When applied, the low viscosity adhesive flows through these openings to some extent and forms rivet-shaped beads or heads on the underside of the screen bar. When solidified, these beads mechanically lock the screen to the screen bar. These openings may be on the order of 1/32" (0.08 cm) round or square. This dimension may be varied as desired.

[0163] Further, adhesive bond can be lost if, for example, residual processing lubricants are not removed prior to applying the adhesive to the screen bar, if extreme and sudden temperature changes occur, if improper surface treatment or improper preheating of the screen bar is done, or if the adhesive is applied while too cold. For these reasons, both mechanical and electrostatic bonding are preferred. If, for example, the electrostatic bond is lost because of excess processing lubricants, the mechanical interlocking assures bonding. As discussed above, perforations in the screen bar adjacent to the step are the preferred mechanical interlock.

[0164] The adhesive is allowed to cool and set in the groove 32 of the screen bar 30a or along the step 32' of screen bar 30a'. Then, the segment of screen bar 30a or 30a', which includes the adhesive 36 or 36', can be stored for any desired time period, and used at a later date. Typically, the screen bar and adhesive assembly is sold in a standard lineal format typically 12 feet (3.6 meters) long. As discussed above, the lineals are cut to size and made into screen frames using corner keys or otherwise, in accordance with conventional practice.

[0165] Another aspect of the invention is the re-melting characteristic of the adhesive used. Generally speaking, a preferred adhesive (1) is applied easily, in liquid (e.g., melted (preferred) or solvated) form, (2) solidifies after application to the screen bar (for storage, shipment, assembly of the screen frame, etc.) and then (3) can be re-melted or reactivated (liquefied) during application of the screen to secure the screen to the screen frame.

[0166] The adhesive family known generally as "hot melt adhesives" have been found to have these attributes, since they can be applied in liquid form, solidify and then can be remelted or "re-activated" at the time of securing the screen (i.e., screen assembly).

[0167] Hot melt adhesives in a solvated, liquid form, can also be used. They are liquefied by the use of solvents such as toluene, MEK (methyl-ethyl-ketone), acetone, and the like. Once solvated, they are applied in liquid form and solidify upon solvent evaporation. They can then be re-melted in the same way the non-solvated forms are. The solvated forms, however, are less desirable, since the solvents add costs, and the evaporated solvents are typically toxic when inhaled.

[0168] The curable type of hot melt adhesives, known as "hot melt polyurethane adhesives" (i.e., PUR's or HMPUR'S) can also be used for this invention, if the adhesive is re-activated (at the time of securing the screen) before it cures. The window of time available, between application to the screen bar and cure, depends upon the adhesive formulation. For instance, Henkel macromelt adhesive A4676 is a hot melt polyurethane adhesive which has approximately four days before it is cured to the point where reactivating cannot occur, effectively. Also available, with similar s characteristics, is HL9527 available from European Fullers, Rangeview Road, Mississauga, Toronto, Ontario. Essentially, these adhesives react with the moisture in the air, causing permanent molecular cross-linking and thus become unmeltable (thermoset). The act of curing or cross-linking of the polyol and the isocyanate in these adhesives precludes the resultant polyurethane from remelting.

[0169] The A4676 adhesive, for example, has an acceptable application melt temperature of 110°C and a green strength (tensile strength, before cure) of 4 to 5 pounds per linear inch of screen) which is more than adequate to secure the screen, once applied. The adhesive, upon curing, has a tensile strength of 2300 lb., a heat resistance temperature of 300°C and a viscosity of 100 poise at 230°C. The advantage to this type of adhesive is the low application temperature and the relatively high heat resistance temperature, once cured. The disadvantage is the fact that the assembly must be completed shortly after the application of the adhesive to the screen bar. Thus, this type of adhesive has limited use. For the majority of applications, when the screen bar is stored for prolonged periods before screen assembly, the regular hot melt (non-curing type) adhesive must be used. For this reason, the regular hot melt type of adhesive is most preferred for practicing this invention.

[0170] The temperature during remelting of the adhesive is typically limited to below 400°F., preferably at 350°F, to prevent smoke. Hotter temperatures may be used, if any fumes exuded by the screen and/or adhesive are evacuated, trapped, and filtered or recycled.

[0171] The use of B-stage epoxy adhesive appears to be not nearly as practical for this invention. They could be made to work if formulated to be applied in a high enough viscosity state to allow handling, once applied to the screen bar; to have a high enough tack or green strength to secure the screen before cure; and to have a long enough shelf life, once applied to the screen bar, to allow screen assembly in time before natural crosslinking occurs. All of these conditions, however, make these adhesives difficult to work with in this environment. Another major drawback with these adhesives is the need for a long cure time at elevated temperatures. Typically, this requires the use of an oven. High intensity lasers have been used to greatly speed up the cure time, but may be impractical, from a cost perspective, for this invention.

[0172] As noted above, it is particularly desirable to reduce cycle time by extracting the insertion device (e.g., insertion pins) as soon as the adhesive in the vicinity of the pins solidifies. For a clean appearance, it is necessary to wait until the pins can be extracted without formation of strings of adhesive during extraction. The choice of adhesive can influence the cycle time. In particular, adhesives that tend to shear without forming strings are preferred based on this criterion. A preferred material is Henkel Macromelt 6071 adhesive, which has a heat resistance temperature of 70 C, and a melting temperature below 100 C.

[0173] An acceptable degree of bonding can occur without encapsulation of the strands of the screen-into the adhesive. Therefore, encapsulation is not essential to this invention. It is, however, preferred to encapsulate the strands of the screen using the adhesive, since this results in mechanical bonding as well as adhesive bonding. Further, encapsulation allows visual assurance that full melting and bonding have occurred.

[0174] For straight adhesion, without encapsulation, the adhesive can be applied as a film in a layer having a thickness between about 0.0005 to about 0.020 inches (0.00127 to 0.005 cm), and preferably, between about 0.003 to about 0.020 inches (0.00762 to 0.05 cm). The film option, if deemed acceptable by users, has the advantage of faster application speed and less cost. Whether a film or a bead of adhesive is used is really a matter of the degree of bond certainty that is desired by the particular user. When using a bead of adhesive, a layer having a thickness between about 0.020 to about 0.250 inches (0.05 to 0.64 cm) is preferred. When a bead is used, it is preferred to apply the adhesive in an amount to provide a layer having a thickness between about 0.030 to about 0.0.050 inches (0.076 to 0.127 cm). This amount is sufficient to provide encapsulation.

[0175] An advantage of using a bead of adhesive in a groove (over a film of adhesive in a groove or along a bottom of a step or lip) is that the bead can be mechanically trapped by the walls of the groove, if the walls of the groove are tapered slightly to form a smaller spacing at the top (opening) than at the bottom.

[0176] In the exemplary embodiments of the invention, the primary mode of cooling at the time of screen assembly (as opposed to the time of application of the adhesive) to the screen bar occurs by conduction of heat into the aluminum substrate (screen bar) and secondarily, by convection/conduction into the surrounding air. Although it is also possible to allow cooling to occur naturally to minimize process complexity, forced cooling (by methods such as forced ambient or chilled air) is quicker. If forced air cooling is used, it may be either attached to the insertion tool (as in FIGS. 2-5) or in the form of a general fan or blower blowing air over the entire assembly or focused on the screen bar.

[0177] Forced cooling may be desired when hot ambient conditions exist or if the screen bar is preheated. Also, the screen bar must be cool enough to avoid remelting of the adhesive after the adhesive has cooled.

[0178] Because the preferred mechanism of cooling includes heat sinking into the screen bar, it is important to use a minimum amount of adhesive to avoid a thick barrier of low conducting adhesive that would interfere with heat flux from the hot adhesive to the screen bar.

[0179] For the adhesive to bond to the strands of the screen, it is necessary for the adhesive to cool below its melt point. For this reason, in this embodiment, it is preferred to utilize an adhesive (such as a crystalline adhesive) having a sharp melt point, so that the adhesive solidifies soon after cooling begins.

[0180] The adhesive also must provide adequate holding strength over the full range of service temperatures. Hot melt adhesives, particularly, polyester and polyamide adhesives have been shown to offer good flow and adhesive characteristics over the full temperature range experienced in service. Additionally, and when desired, these adhesives also provide good encapsulation (mechanical anchoring of the screen strands) characteristics.

[0181] Generally speaking, conventional thermoplastic pure polymer resins such as polyamide, polyester, polycarbonate and the like tend to have higher melt flow viscosities than is acceptable, resulting in lower screen holding strength than desired, because it is difficult to embed the strands of the screen in these adhesives. Straight polyamide (e.g., nylon) and polyester (PET) polymer resins (plastics) work only to a limited degree, since the viscosity and melt temperatures are higher with these pure resins. Also, these resins include none of the desirable additives, which lower viscosity and melt temperature and improve surface wetting (via surfactants). Although pure tensile holding strength may be achieved with high viscosity resins and adhesives, the lack of adequate holding strength puts a greater demand on the electrostatic or adhesive bonding component.

[0182] The polyester and polyamide families of adhesives have shown good performance at elevated service temperatures. Therefore, these adhesives are preferred. Nevertheless, this invention is not limited to these adhesives. Rather, any suitable hot melt or equivalent adhesive or thermoplastic resin having the required heat resistance temperature, bond strength and viscosity characteristics can be used.

[0183] Most manufacturers follow ANSI and CGSB standards for load requirements. Experiments show that in order to pass the CAN/CGSB 79.1 type II standard, a retention strength of approximately 9 pounds per inch width of screen is required when the load is applied in the plane of the screen (i.e., tensile loading). This value was obtained from tests conducted at room temperature. This value was measured using a 1 inch (2.5 cm) long screen bar sample with a piece of screen 1 inch by 2 inches (2.5 cm x 5.1 cm) attached. A tab attached to the screen bar and coplanar with the screen was inserted into one jaw of an Instron tensile testing machine while the screen was inserted into the other jaw. Samples were then loaded to the break point, which was recorded.

[0184] Existing spline retention technology which meets this load requirement of 9 pounds at room temperature was measured to drop to approximately 4 pounds per inch at 60°C. At

[0185] -40°C, there was not a significant change in retention strength compared to room temperature measurements. The strength of hot melt adhesives also decreases at elevated temperatures, but may increase at slightly lower temperatures. In experiments, a strength of 30 to 35 pounds per inch was obtained at room temperature conditions using the Henkel 6206 adhesive. At 60°C, the strength was measured to be 20 pounds per inch. The present invention thus gives over three times higher retention strength over current spline technology over the range of service temperatures. This was unexpected!

[0186] In choosing a hot melt adhesive or thermoplastic resin to meet the requirements of hot weather conditions, one should consider various temperature values specified by the manufacturers of these adhesives or resins. Specific values include melt and glass transition temperatures as measured using differential scanning calorimetry (DSC ASTM test #E 698), heat resistance temperature using ASTM test method #D 2293 and softening point, usually determined using the ball and ring test, ASTM #E 28. Generally, the ball and ring temperature is approximately 8 to 10°C greater than the melt temperature for polyester and polyamide adhesives.

[0187] The most important temperature value relating to selection of materials for this invention is the heat resistance temperature, since this value indicates the temperature at which movement under load occurs. This is referred to as "creep". Typically, a 500 gram load is used on a 1 inch by 1 inch (2.5 cm x 2.5 cm) lap seam (as opposed to a butted seam). The heat resistance temperature is an indication of when an adhesive begins to rupture under loaded conditions.

[0188] In short, the theoretical minimum heat resistance temperature allowable is the design ambient temperature. Nevertheless, practically speaking, it is generally necessary to have a heat distortion temperature to perform in the ambient conditions expected. In most areas (excluding tropical climates), this temperature is considered to be about 35 to about 45°C. Although it is most preferred to have adequate strength to hold screen tension up to 85°C for shipping in closed containers (as per MIL-STD A10), a reasonable upper ambient limit (desert) temperature is considered to be about 50°C, where full performance strength is required. With the sun directly hitting dark colored screen bars, an additional 20°C can be reached. Thus, a preferred minimum heat resistance temperature is about 70°C for service, and about 85°C for shipping. In temperate climates, it is generally acceptable to have a heat resistance temperature of about 55°C. This compensates for a 35°C upper limit on ambient temperatures and a 20°C differential for sunshine on dark colors. In tropical climates, these values are 45°C plus a 20°C differential, which yields a minimum of about 65°C.

[0189] Because the upper limit for ethylene vinyl acetate (EVA) type adhesives is generally considered to be about 75°C, this type of adhesive is acceptable from a temperature standpoint. However, EVA hot melt adhesives are not preferred because plasticizer migration from the screen may occur at elevated ambient temperatures resulting in loss in structural integrity, i.e., tensile strength.

[0190] In the adhesive industry, a 15 to 20°C margin of safety is generally recommended between the heat resistance temperature of the adhesive used and the expected service temperature. Thus, an 85°C service temperature expectation would suggest that the adhesive have a heat resistance temperature of about 100 to about 105°C. Adhesives in the polyamide or polyester family of hot melts meet this criterion. It is, however, more preferred to have an adhesive with a heat resistance temperature of about 120°C. This gives a 35°C margin of safety over the 85°C shipping temperature and 50°C above the 70°C dark color desert conditions under direct sunlight. Again, polyamide and polyester hot melt adhesives meet these values.

[0191] Thus, the adhesive should have a heat resistance temperature of not less than about 35°C. A heat resistance temperature between about 55°C and about 180°C is preferred, with between about 85°C and about 150°C being more preferred and between about 100°C and about 130°C being most preferred. Thermoplastic (hot melt) adhesives or resins are acceptable. These adhesives allow replacement of the screen by using a hot tool to first liquefy and allow removal of the old screen, and then replacement in a manner discussed herein. If desired, replacement screen also could be attached using conventional spline techniques, when using screen bar that has a spline groove. For this reason, a groove is preferred over a simple step.

[0192] The melting point value specified by the adhesive manufacturers is also important. This value is the temperature at which the adhesive begins to liquefy and flow under shear stress.

[0193] Although heating the adhesive by convection is preferred, a heated tensioning tool may be used. Because the preferred tensioning tool includes a plurality of pins that remain in the adhesive till the adhesive re-solidifies, the use of heated pins is expected to increase the cooling time. Nevertheless, if a heated insertion tool is used, it is important to use an adhesive having a low enough melt temperature (e.g., about 100° to about 225°C (maximum)) to allow a heated tool temperature within an operating range, which limits smoke production. Smoke can be generated from either the adhesive or the coating on the screen. This range is about 200°C to about 500°C (with about 200°C to about 400°C being preferred, about 200°C to about 300°C being more preferred and about 250°C to about 300°C being most preferred) with minimum smoke production. The corresponding maximum ball and ring temperatures of the adhesive are about 210°C (acceptable), about 150°C (preferred) and about 120°C (most preferred). Hot melt adhesives selected from the group consisting of polyester, polyamide, polyolefin, polypropylene, polyurethane, butyl and ethylene vinyl acetate (EVA) give satisfactory bond strength at s room temperature (about 20°C and below). However, only the polyester and polyamide adhesive families seem to perform particularly well at elevated temperatures. Although the EVA's may generally work well, they are not preferred due to excessive plasticizer migration, which may occur at elevated ambient temperatures. This causes loss of bond strength.

[0194] Table I shows polyamide and Table 2 shows polyester hot melt adhesives that meet the high temperature requirements and melt flow characteristics. In these tables, the Macromelt adhesives are available from Henkel, Elgin, Illinois, whereas the Bostik adhesives are available from Bostik, Middleton, Massachusetts and the letter "a" indicates "acceptable" while the letter "p" indicates "preferred".

TABLE 1

	Polyamide Adhesive	Ball and Ring Temp. °C	Heat Resistan ce Temp. °C	Viscosity / (temp.) Poise/(° C)	Tensile Strength psi
6000-a	Macromelt	200	155	4/(200)	1900
6202-p	Macromelt	150	110	50/(210)	450
6206-a	Macromelt	180	145	40/(210)	1100
6211-a	Macromelt	145	125	25/(210)	370
6212-a	Macromelt	110	80	35/(200)	500
6071-a	Macromelt	95	70	10/(160)	210
7239-p	Bostik	150	115	35/(200)	385
4252-p	Bostik	150	110	22/(205)	580
6240-a	Bostik	185	145	16/(230)	N/A

TABLE 2

	Polyester Adhesive	Ball and Ring Temp. °C	Heat Resistan ce Temp. °C	Viscosity / (temp.) Poise/(° C)	Tensile Strength psi
4101-p	Bostik	120	95	145(230)	3400
4103-p	Bostik	135	110	425(225)	2290
4156-a	Bostik	160	137	23(215)	2700
4175-a	Bostik	200	N/A	900(225)	N/A
4178-a	Bostik	145	120	1000(21 5)	3000
	Bostik	150	N/A	900(215)	N/A

TABLE 2 (continued)

	Polyester Adhesive	Ball and Ring Temp. °C	Heat Resistan ce Temp. °C	Viscosity / (temp.) Poise/(° C)	Tensile Strength psi
5182-a					
	Bostik	150	N/A	340(200)	N/A
7116-p					
	Bostik	190	170	200(215)	700
7199-a					

[0195] Another property that may be important, and one that separates thermoplastic (hot melt) adhesive from thermoplastic resins (plastics) is surface wetting. In this respect, melt viscosity is one of the most important properties of a hot-melt adhesive. In general, for a given adhesive, as the temperature increases, its viscosity decreases. Therefore, for a given hot-melt adhesive formulation, the temperature of the adhesive during application controls the viscosity, which greatly influences the extent of surface wetting. The bond formation temperature is a minimum below which surface wetting is inadequate. A hot-melt adhesive is applied at a running temperature, at which the viscosity is sufficient to wet surfaces. See the Engineered Materials Handbook, Vol. 3, "Adhesives and Sealants", ASM International Handbook Committee, page 80.

[0196] Preferably, the adhesive not only melts and flows, but also has a wetting action to spread easily over the surface of the strands of the screen to secure and/or encapsulate them. Adhesive manufacturers add waxes and plasticizers as surfactants to promote surface wetting. The amounts of these additives remain proprietary to the adhesive manufacturers. Loads applied to the screen must be carried by the adhesive. The adhesives listed in Tables 1 and 2 give acceptable bond and tensile strength to meet the load requirements of the installation. Preferably, the tensile strength of the adhesive is over 200 psi, but many adhesives having a lower tensile strength can still effectively carry the loads. Strand encapsulation enhances bond strength between the screen and the adhesive and mechanical interlocking between the adhesive and the screen is preferred to ensure full bond potential. Perforations in the screen bar, discussed above, is the preferred method of mechanical interlocking.

[0197] There was an initial concern that polyamide adhesives and EVA would soften over time while in contact with plasticized PVC screen, due to the potential plasticizer migration. (Polyester adhesives do not have the same susceptibility to plasticizer migration and thus, softening characteristics.) This concern with polyamide adhesives and EVA, however, has not been demonstrated in practice. It is believed that the amount of plasticizer available for migration is very low. For this reason, polyamides are, along with polyester adhesives, preferred.

[0198] Good weathering characteristics are advantageous, because many screen assemblies are exposed to full sunlight and extreme whether conditions. Industry standards generally demand mechanical properties to be, maintained over a ten year period. However, twenty years is preferred.

[0199] To enhance weatherability, it is generally known to add to the adhesive carbon black for blocking ultraviolet (UV) light, as well as light absorbers and light stabilizers. Also, adding enough carbon black to make the adhesive opaque is sufficient to block UV light. Generally, 0.5 to 2% by weight of the adhesive is adequate to block UV light, and 1 to 1.5% by weight is sufficient to make the adhesive opaque. Diminishing returns are experienced above 2%, and mechanical properties also can be adversely affected. Carbon black is preferred from a cost and performance standpoint. Alternatively, instead of adding carbon black to the adhesive to block UV from the sun, TiO_2 may be used. This would achieve a white color.

[0200] Benzotriazole is a suggested additive to act as a UV absorber for both polyamide and polyester adhesives. An example is Tinuvin 234, available from Ciba-Geigy, which is a 100% active chemical. This chemical may be added to the adhesive in an amount of 0.05% to 0.3%, with 0.1% be a typically specified amount, by weight.

[0201] Products which act as "hindered amine light stabilizers" (HALS) may also be added to the adhesive, in an amount between 0.05 to 0.3% by weight. 0.1% is a typically specified amount. Tinuvin 622, available from Ciba-Geigy, is a 100% HALS and is recommended for polyamide and polyester adhesives.

[0202] It is believed that using the accepted adhesives in a foamed form (with 20%-70% lower density) has an advantage of giving a larger bead size, for example, for a given mass per unit length - thus, lowering cost. A larger diameter bead increases the bonding area, which improves the bond strength. Also, the insertion speed is theoretically increased, as less mass is heated and melted from a given bead size. A Nordson model FM190 hot-melt dispensing unit is designed to apply foamed adhesives in bead form. Nitrogen is generally used as the foaming agent in such foamed adhesives.

[0203] The screen bars of this invention are designed to meet both the Canadian and U.S. type II standards for load resistance and pull out strength. (ANSI-SMA SMT 31- and CAN-CGSB-79.1-M91). In Canada, the load resistance test for a type II screen requires that a 75 lb. weight, or 37 lb. for a type I screen distributed over a one foot square diameter, be placed in the center of a three foot by three foot pre-clamped screen. The Canadian pull out test resembles a tensile test in which a one inch section of screening and screen bar are subjected to tensile loading in, for example, an Instron tensile testing machine. To satisfy this pull out test, screen samples must demonstrate at least 9 lb./inch resistance to tensile loads. If the spline or glue joint separates under a 9 lb. load, the screen fails the pull out test for type II screens.

[0204] The screen bars of this invention were designed to meet the customary screen dimensions as follows:

BayForm B516	BayForm B38
D-.17 inches T-.020 inches	D-.235 inches T-.023 inches

[0205] The above dimensions, shown in FIG. 6, are typical in the screen industry, whereby "D" represents the height of the tensioning step, "T" represents the thickness of the bar material, which is typically aluminum, and E represents Young's modulus of the screen bar material (10.3×10^6 psi for aluminum, 30×10^6 for steel). It is known through experience that a B516 aluminum screen bar generally fails the 75 lb. load test if its thickness (T) falls below .018 inches. Similarly, an aluminum screen bar manufactured to the B38 standard generally is known to fail the 75 lb. load test if its thickness (T) falls below .020 inches. When the gluing methods of the present invention are employed, however, instead of the prior art's spline technique, a thickness "T" of less than .018 inches for the B516 bar, and a thickness "T" of less than .020 inches for a B38 bar was sufficient to meet the 75 lb. load test. Moreover, the present gluing technique was tested in accordance with the Canadian 79.1 type II standard pull out test parameters. Under this test, a B38 type screen bar must meet at least 9 lbs. per inch in tensile load before the spline pulls out, or the screen separates. Using spline technology, a B38 bar thickness "T" was reduced from .023 inches to .018 inches for a standard spline product, and this product resulted in a tensile load of 6 lbs./inch tensile force test result, thus failing the test. When a B38 style bar having a thickness of only 0.016 inches and a glued joint pursuant to the teachings of this invention was similarly tested, it had a tensile force of 25 lbs., passing the test by a factor of safety of almost 3.0 (or of almost 6.0 for a type I screen).

[0206] Accordingly, the screen bars of this invention can be made thinner and stronger than prior art screen bars using splines. According to solid mechanics analysis, the conventional spline screen bar cross-sectional ratio "D(in.)/T^2(in.^{2})E(psi)" should be no greater than

[0207] 41.3×10^{-6} to meet the 75 lb. test. Using the present invention, the inventor contemplates achieving a ratio greater than 41.3×10^{-6} to meet the CGSB-CAN 79.1 type II specification, and even 48.5×10^{-6} or greater, with ratios as high as 65×10^{-6} without failing the pull out test. Below in Table 3, examples of pull out test results for various thicknesses and tensions step heights employing a spline (Sets 1, 2 and 3) and the adhesive method of this invention (Sets 4, 5 and 6) are provided, easily demonstrating that the improved method of this invention increases the performance of screens subjected to a tensile load.

[0208] A screen and frame when so joined by a method according to the invention can pass a 37 lb. load test in accordance with break load at a thickness "T" at least about 10% less than the thickness "T" of a passing spline-retained screen and frame of like material undergoing said load test. For example, in Table 3, Set 2 specifies a spline type screen that failed the test, using 0.019 in. thick material. Set 5 specifies a screen according to the invention that passes the test with only 0.016 in. thick material. Because 0.016 is less than 0.019 (a failing spline thickness) by at least 10%, and a passing spline frame would require thickness greater than 0.019, an assembly according to the invention can easily be at least 10% thinner than a passing spline-retained screen frame of like material.

[0209] A screen and frame when joined according to the invention has a break load test value of at least 50% greater than a spline retained screen of like thickness "T" and like tensioning step height "D". For example, in Table 3, Set 3 specifies a failing 0.016 spline with a 0.23 in. step height. The largest pull out load in sample set 3 is 5.769 lb. Set 5 specifies a passing frame screen assembly according to the invention, having the same thickness and the same tensioning step height. The minimum break load in sample set 5 is 18.22 lb., which is more than three times the pull out load of the spline type assembly of set 3.

TABLE 3

PULL OUT / BREAK LOAD TEST ANALYSIS	
Set 1: T=0.018 in., D=0.200 in. with **spline**, $D/T^2E = 59.9 \times 10^{-6}$	
Sample code	**Pull Out load**
FM1	5.922
FM2	6.276
FM3	7.713

TABLE 3 (continued)

PULL OUT / BREAK LOAD TEST ANALYSIS	
Set 1: T=0.018 in., D=0.200 in. with **spline**, D/T^2E = 59.9 x 10^{-6}	
Sample code	**Pull Out load**
FM4	8.056
FM5	7.683
FM6	6.824
Set 2: T=0.019 in., D=0.200 in., with **spline,** D/T^2E = 54 x 10^{-6}	
Sample code	**Pull Out load**
FP1	8.236
FP2	7.731
FP3	6.156
FP4	8.851
FP5	7.570
FP6	5.503
Set 3: T=0.016 in., D=0.230 in., **spline,** D/T^2E = 87.2 x 10^{-6}	
Sample code	**Pull Out load**
016P-15.769	
016P-25.603	
016P-35.557	
016P-44.416	
016P-55.103	
016P-63.850	
Set 4: T=0.0235 in., D=.230 in., Bostik 4156 polyester **adhesive,** D/T^2E= 40.4 x 10^{-6}	
Sample code	**Break load**
IB4145-1	30.94
IB4145-2	24.21
IB4145-3	29.66
IB4145-4	26.01
IB4145-5	26.78
IB4145-6	24.91
B516=D=0.17,	T=0.020
B38=D=0.230.	T=0.0235
Set 5: T=0.016 in., D=0.230 in., 6206 Henkel **adhesive,** D/T^2E = 87.2 x 10^{-6}	
Sample code	**Break load**
31.64	
19.83	
18.22	
20.52	
22.62	
24.93	
Set 6: T=.0235 in., D=0.230 in., with Henkel 6206 with **adhesive,** D/T^2E = 40.4 x 10^{-6}	
Sample code	**Break load**
28.15	
30.56	
28.08	

TABLE 3 (continued)

PULL OUT / BREAK LOAD TEST ANALYSIS	
Set 5: T=0.016 in., D=0.230 in., 6206 Henkel **adhesive,** $D/T^2E = 87.2 \times 10^{-6}$	
Set 6: T=.0235 in., D=0.230 in., with Henkel 6206 with **adhesive,** $D/T^2E = 40.4 \times 10^{-6}$	
Sample code	**Break load**
27.14	
25.38	
30.19	

[0210] Although hot melt adhesives and thermoplastic resins are discussed above, the inventor contemplates that pressure sensitive adhesives and like bonding agents that provide acceptable results also could be used, if desired.

Other Screen Bar Configurations

[0211] Although the exemplary embodiments described above include a groove or tensioning step, other screen bar configurations may be used. For example, the screen bar may be flat. Alternatively, the screen bar may have a ridge.

[0212] Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claim should be construed broadly, to include other variants and embodiments of the invention which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

Claims

1. A method for securing ventilation cloth to a screen frame, comprising the steps of:

(a) orienting a screen frame in an approximately vertical position, the screen frame having a plurality of segments, each segment having a mounting surface on a face thereof, at least one of said segments having adhesive on the mounting surface thereof;
(b) hanging a ventilation cloth across the mounting surface of said one segment;
(c) providing adhesive in said at least one of the segments;
(d) inserting the ventilation cloth in the adhesive across a length of said one of the segments.

2. The method of claim 1, wherein step (c) includes melting the adhesive.

3. The method of claim 2, wherein:

each of the segments has adhesive on the mounting surface thereof;
step (b) includes hanging the ventilation cloth across the mounting surface each segment simultaneously;
step (c) includes melting the adhesive on all of the segments; and
step (d) includes inserting the ventilation cloth in the adhesive across a length of each of the segments.

4. The method of claim 1, wherein step (a) includes orienting the frame in a position between 0 and 30 degrees from vertical.

5. The method of claim 1, wherein step (d) includes pushing the screen into the adhesive along said one side with an elongated insertion member.

6. The method of claim 1, further comprising the step of clamping the screen frame on four sides simultaneously, before step (b).

7. The method of claim 6, wherein the clamping step includes compressing the frame from the outside on all four sides.

8. The method of claim 5, further comprising, before step (b), the step of loading the frame into a side of an apparatus in which the insertion is performed.

9. A method for securing a ventilation cloth to a screen bar segment, comprising the steps of:

(a) providing a screen bar segment having a mounting surface on a face thereof, the segment having adhesive on the mounting surface;
(b) spreading the ventilation cloth across the mounting surface of the screen bar segment;
(c) melting the adhesive;
(d) inserting the ventilation cloth into the adhesive with an elongated insertion member that extends substantially across a length of the screen bar segment.

10. The method of claim 9, wherein step (d) is performed by moving the insertion member in a single motion normal to the plane of the ventilation cloth.

11. The method of claim 9, further comprising:

applying a release coating to the plurality of elongated insertion member before step (d).

12. The method of claim 9, wherein the screen bar segment is included in a screen frame having at least three segments, the method further comprising orienting the screen frame in an approximately vertical position before step (b).

13. The method of claim 12, wherein

each of the segments has adhesive on the mounting surface thereof;

step (b) includes hanging the ventilation cloth across the mounting surface each segment simultaneously;
step (c) includes melting the adhesive on all of the segments; and
step (d) includes inserting the ventilation cloth in the adhesive substantially across the length of each of the segments.

14. Ventilation cloth insertion apparatus, comprising:

a fixture that orients a screen frame in an approximately vertical position, the screen frame having a plurality of segments, each segment having a mounting surface on a face thereof, at least one of said segments having adhesive on the mounting surface thereof; and
at least one insertion device that inserts a vertically positioned ventilation cloth in the adhesive substantially across a length of said one of the segments.

15. The apparatus of claim 14, further comprising a hanger that hangs the ventilation cloth across the mounting surface of said one segment.

16. The apparatus of claim 14, further comprising a heater that melts the adhesive in said one of the segments.

17. The apparatus of claim 14, wherein each of the segments has adhesive on the mounting surface thereof; the apparatus further comprsing:

a hanger that hangs the ventilation cloth across the mounting surface each segment simultaneously; and
a heater that melts the adhesive on all of the segments;

wherein the apparatus includes at least one insertion apparatus for each respective segment of the frame, for inserting the ventilation cloth in the adhesive across the length of each of the segments.

18. The apparatus of claim 14, wherein the fixture orients the frame in a position between 0 and 30 degrees from vertical.

19. The apparatus of claim 14, wherein the insertion device is a band or elongated insertion member extending substantially across the length of the segment.

20. The apparatus of claim 14, further comprising means for clamping the screen frame on four sides simultaneously.

21. The apparatus of claim 20, wherein the clamping means includes means for compressing the frame from the outside on all four sides.

22. The apparatus of claim 20, wherein the clamping means includes at least one clamping device on a side of the apparatus, said at least one clamping device being capable of movement in a direction normal to a plane in which the frame is positioned to allow the frame to be loaded into the apparatus by way of the side on which said at least one clamping device is located.

23. The apparatus of claim 14, wherein the fixture includes a fixed arm and three movable arms, the movable arms being positionable for clamping frames having multiple sizes between the fixed and movable arms.

24. The apparatus of claim 23, wherein one of the movable arms is movable in a first direction parallel to a length thereof and movable in a second direction perpendicular to the length thereof.

25. The apparatus of claim 23, wherein each movable arm is movable within a respective pair of slidable yolks.

26. The apparatus of claim 23, wherein each arm is positioned substantially at the same height, measured from a plane in which the ventilation cloth lies.

27. Ventilation cloth insertion apparatus, comprising:

a fixture that clamps a screen frame, the screen frame having a plurality of segments, each segment having a mounting surface on a face thereof, at least one of said segments having adhesive on the mounting surface thereof,
said fixture having a plurality of clamping arms, said clamping arms being positionable so that each clamping arm clamps a respective side edge of a respective one of the plurality of sides of the screen frame while attaching a ventilation cloth to the screen frame, wherein each of the plurality of clamping arms is positioned at a common height with respect to a plane in which the ventilation cloth is positioned;
at least one insertion device that inserts a ventilation cloth in the adhesive substantially across a length of said one of the segments.

28. The apparatus of claim 27, wherein each clamping arm clamps a respective outside edge of a respective one of the plurality of sides of the frame, the outside edges of the screen frame being the edges of the segments that are furthest from a center of the screen frame.

29. The apparatus of claim 27, further comprising a heater that melts the adhesive in said one of the segments.

30. The apparatus of claim 27, wherein :

each of the segments has adhesive on the mounting surface thereof;
the heater melts the adhesive on all of the segments; and
the apparatus includes a plurality of insertion devices, each inserting the ventilation cloth in the adhesive across a length of a respective one of the segments.

31. The apparatus of claim 27, wherein the apparatus includes four clamping arms forming a rectangle, and three of the four clamping arms are movable with respect to a remaining one of the arms.

32. The apparatus of claim 31, wherein one of the movable arms is movable in a first direction parallel to a length thereof and movable in a second direction perpendicular to the length thereof.

33. The apparatus of claim 31, wherein each movable arm is movable within a respective pair of slidable yolks.

34. The apparatus of claim 27, further comprising an air actuated shield for protecting a portion of the ventilation cloth adjacent to a corner key in at least one corner of the screen frame.

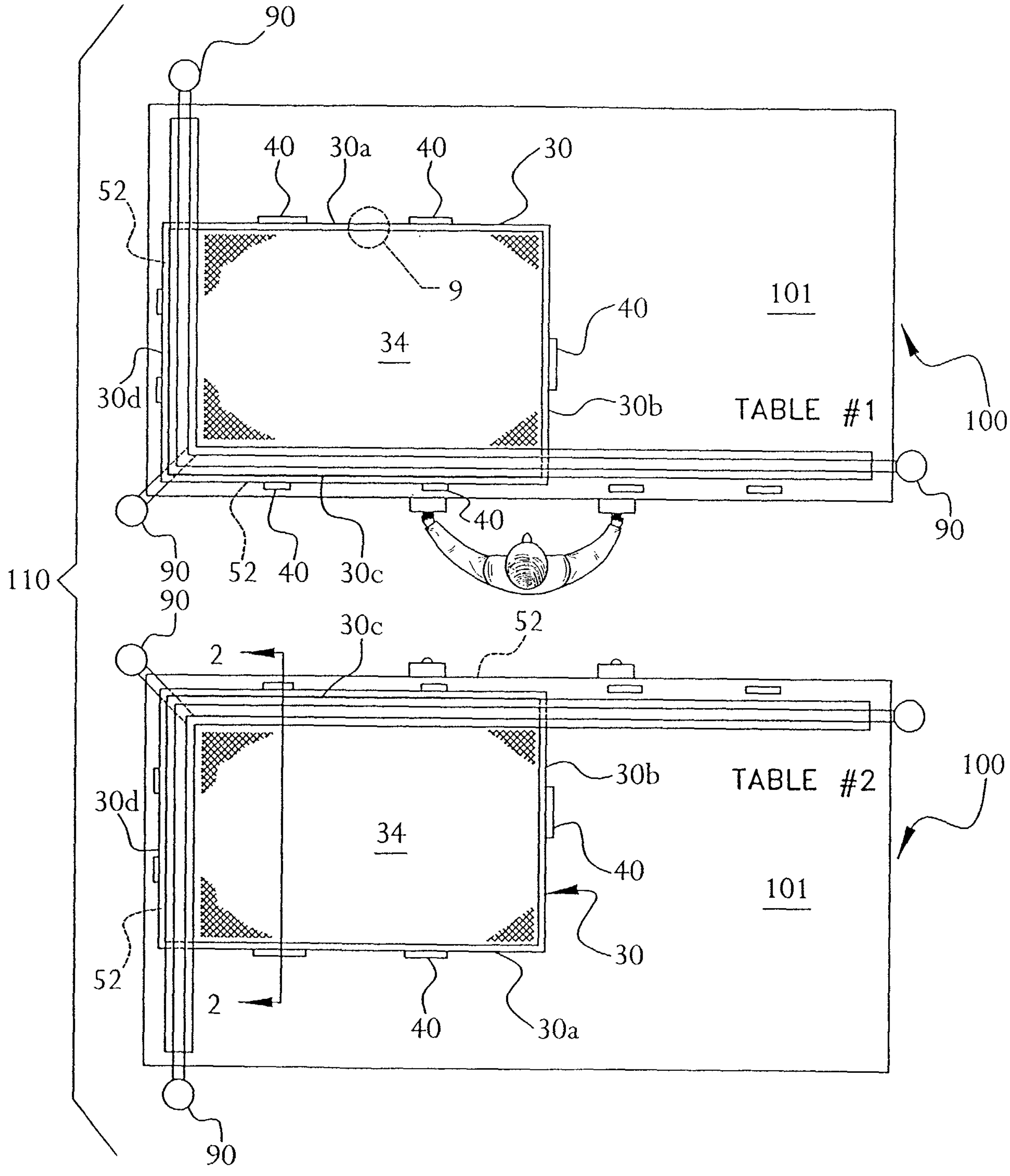
35. The apparatus of claim 27, wherein at least one clamping arm is located on a side of the apparatus and is capable of movement in a direction normal to a plane in which the frame is positioned, to allow the frame to be loaded into the apparatus by way of the side on which said at least one clamping arm is located.

36. A cart for transporting a frame, comprising:

an L-shaped bracket having a side and a bottom portion;
a plurality of clips that hold the frame on the side and bottom portion of the bracket; and
a pivotally mounted finger having a first position parallel to the bracket for loading the frame onto the clips and a second position normal to the bracket.

37. The cart of claim 36, further comprising an actuator, wherein the bracket is mounted to the actuator.

38. The cart of claim 36, wherein the plurality of clips includes at least two clips on the bottom portion of the bracket.


90
40
30a
40
30
52
9
40
101
34
30d
30b
TABLE #1
100
90
40
90
52
40
30c
110
90
30c
52
2
30b
TABLE #2
100
30d
34
40
101
30
52
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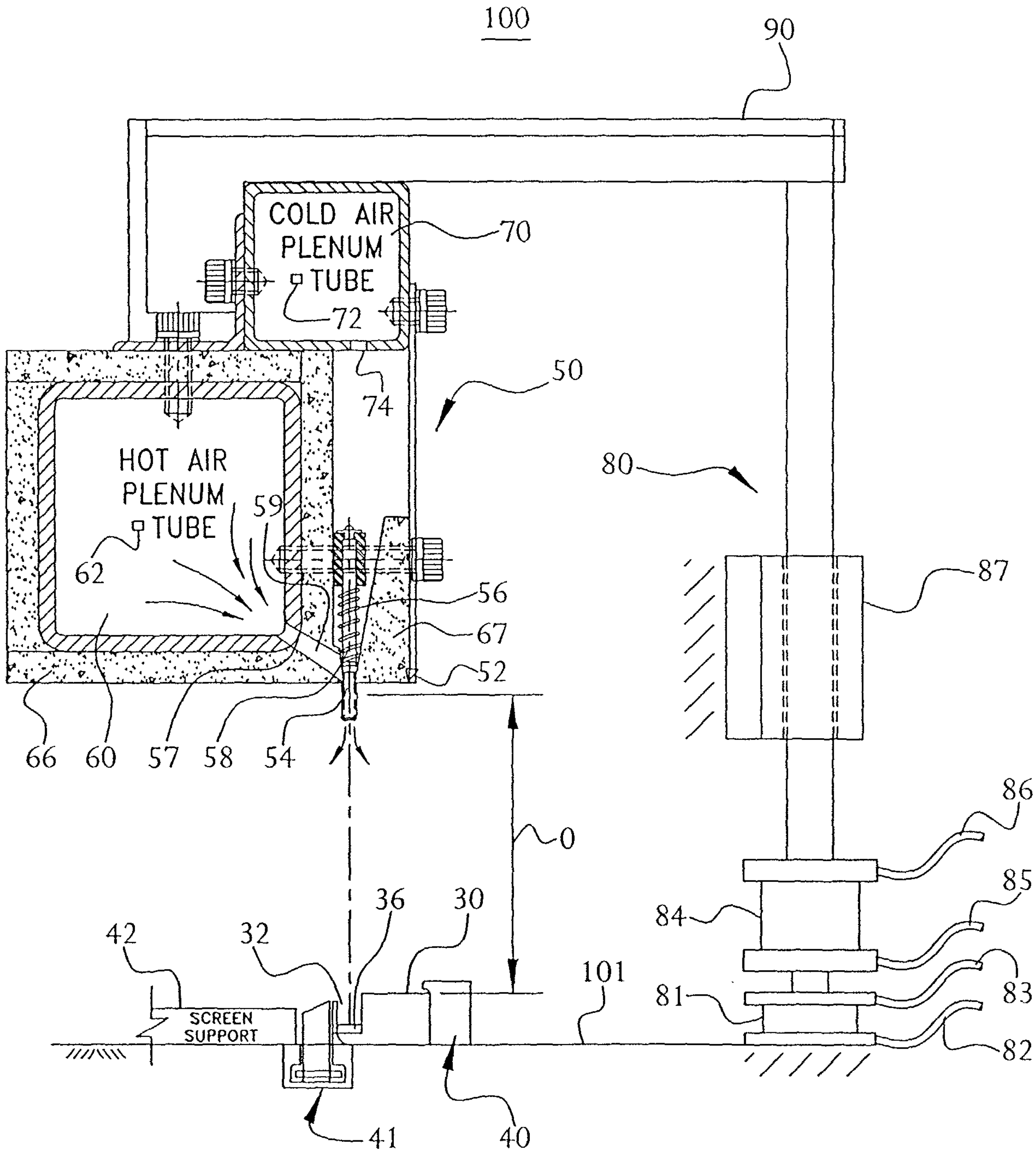
40
30a
90

FIG. 1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90
COLD AIR
PLENUM
TUBE
70
72
74
50
80
HOT AIR
PLENUM
TUBE
59
62
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67
52
87
66
60
57
58
54
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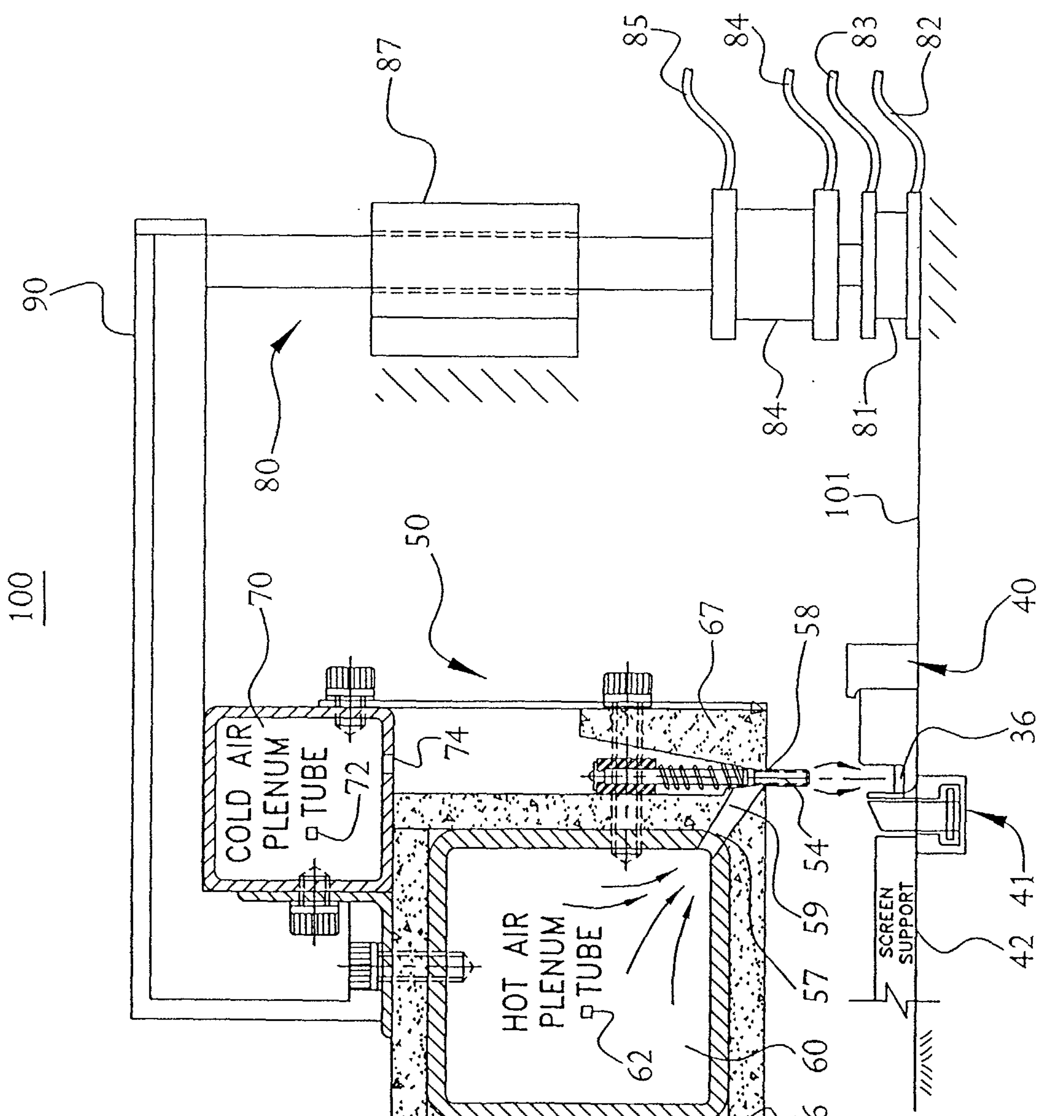
85
84
36
30
83
42
32
101
81
SCREEN
SUPPORT
82
41
40

FIG. 2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SCREEN SUPPORT
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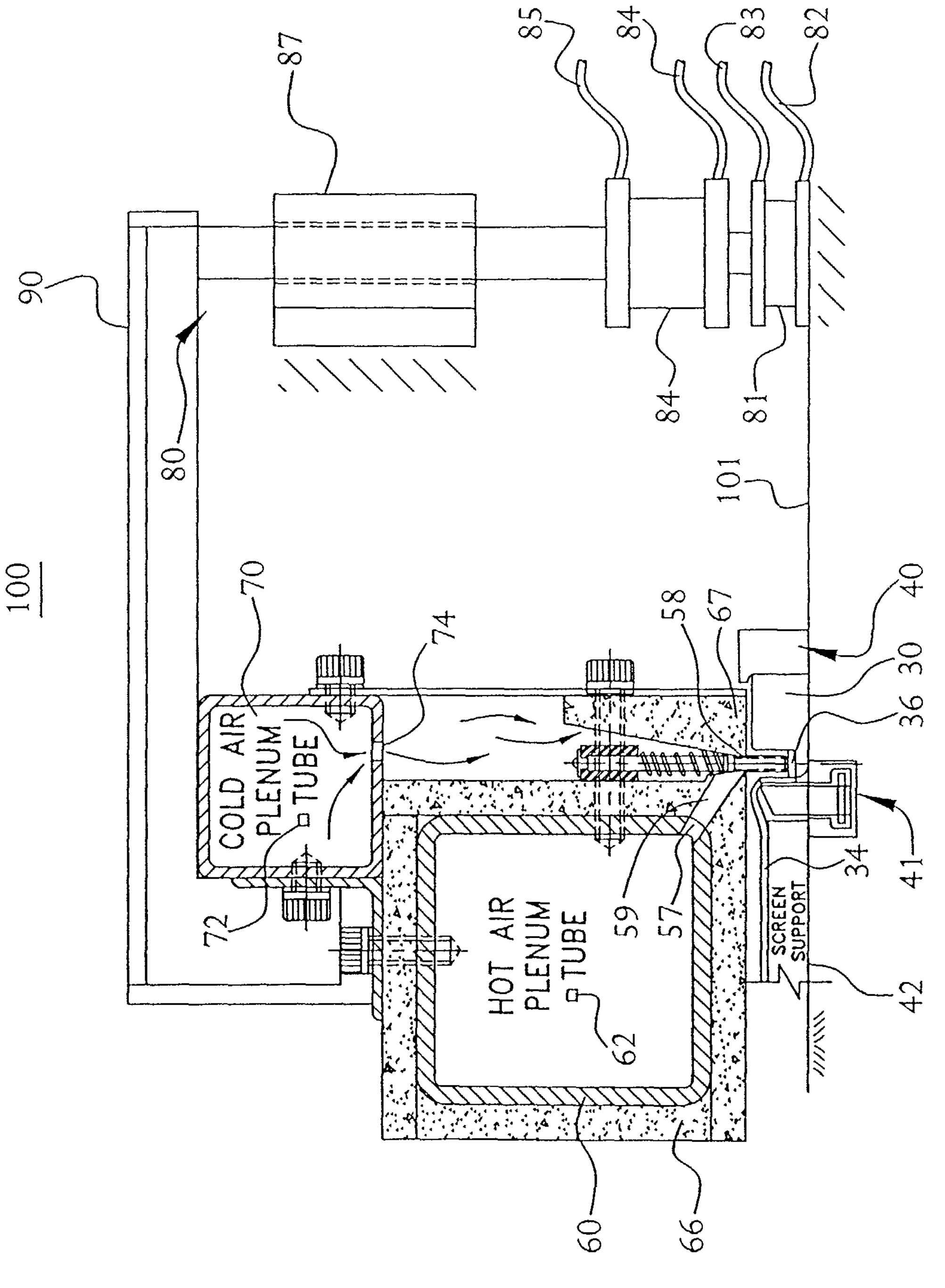
41

FIG. 3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60
66

FIG. 4

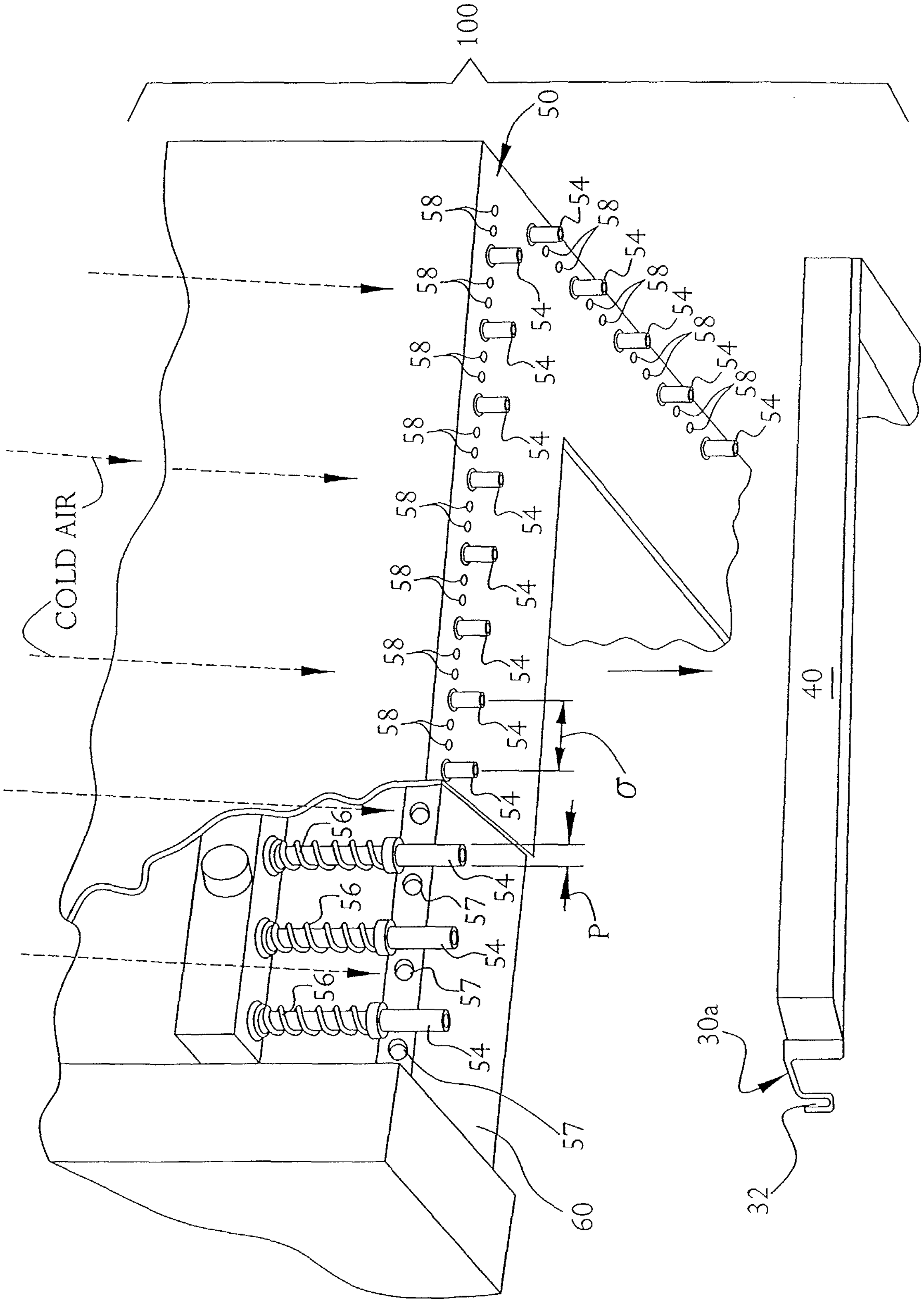


FIG. 5

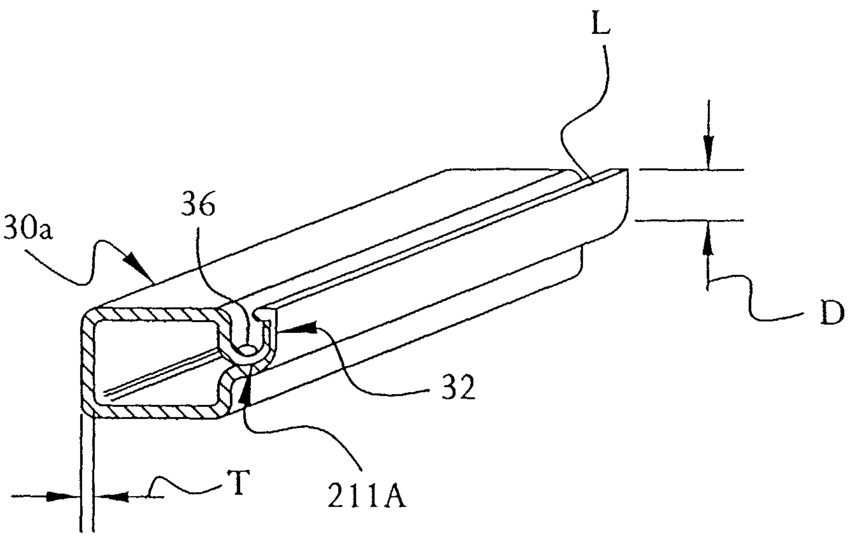


FIG. 6

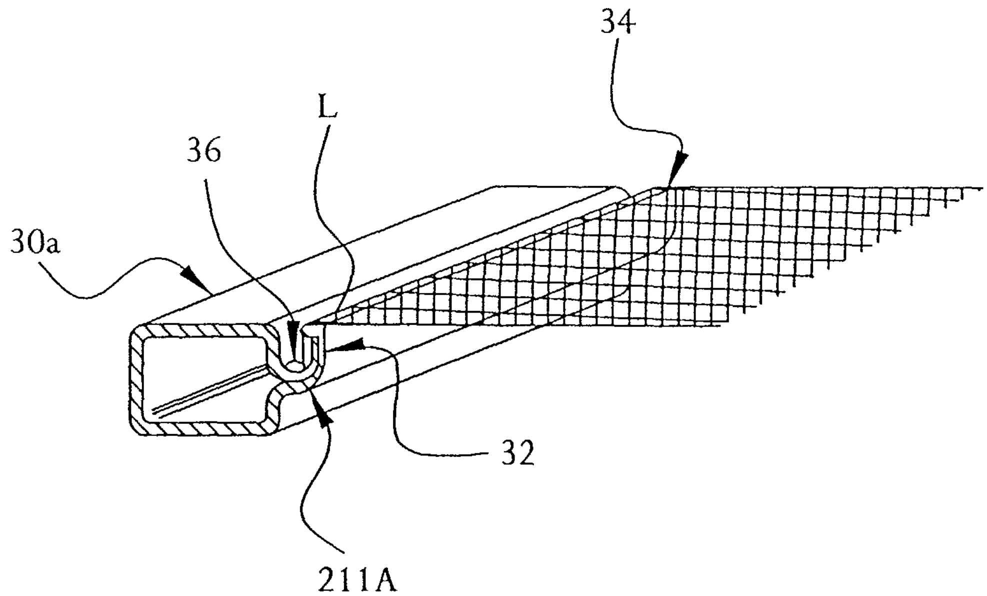


FIG. 7

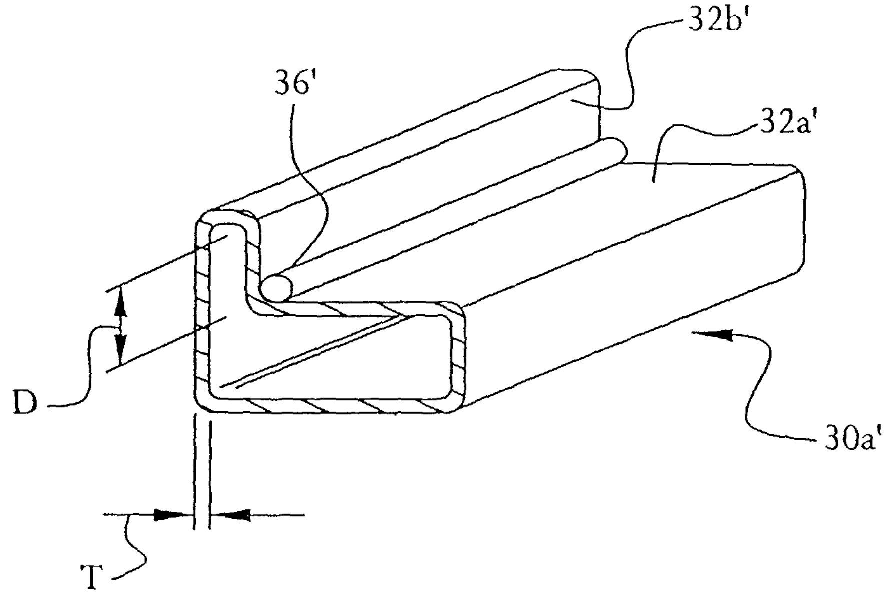


FIG. 8

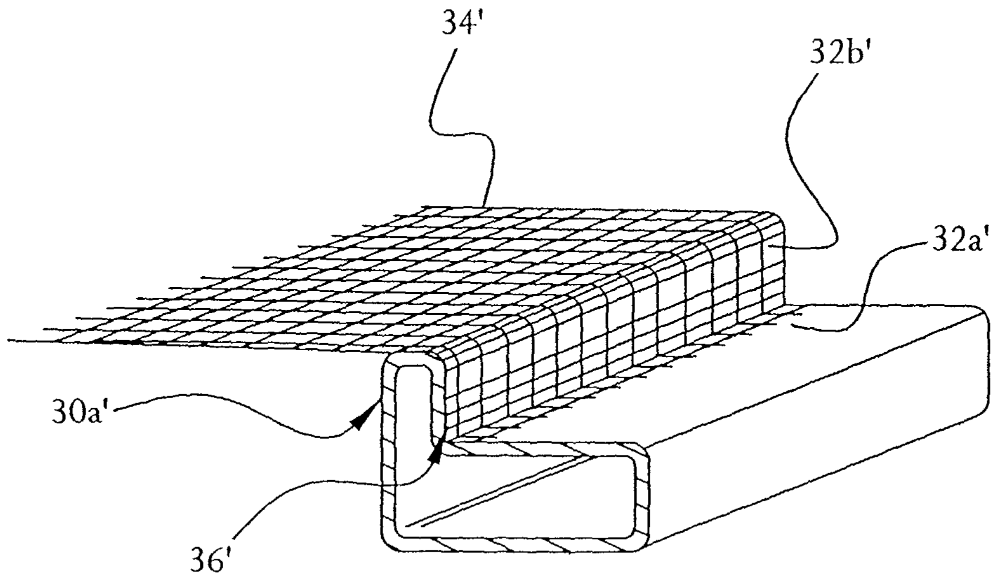


FIG. 9

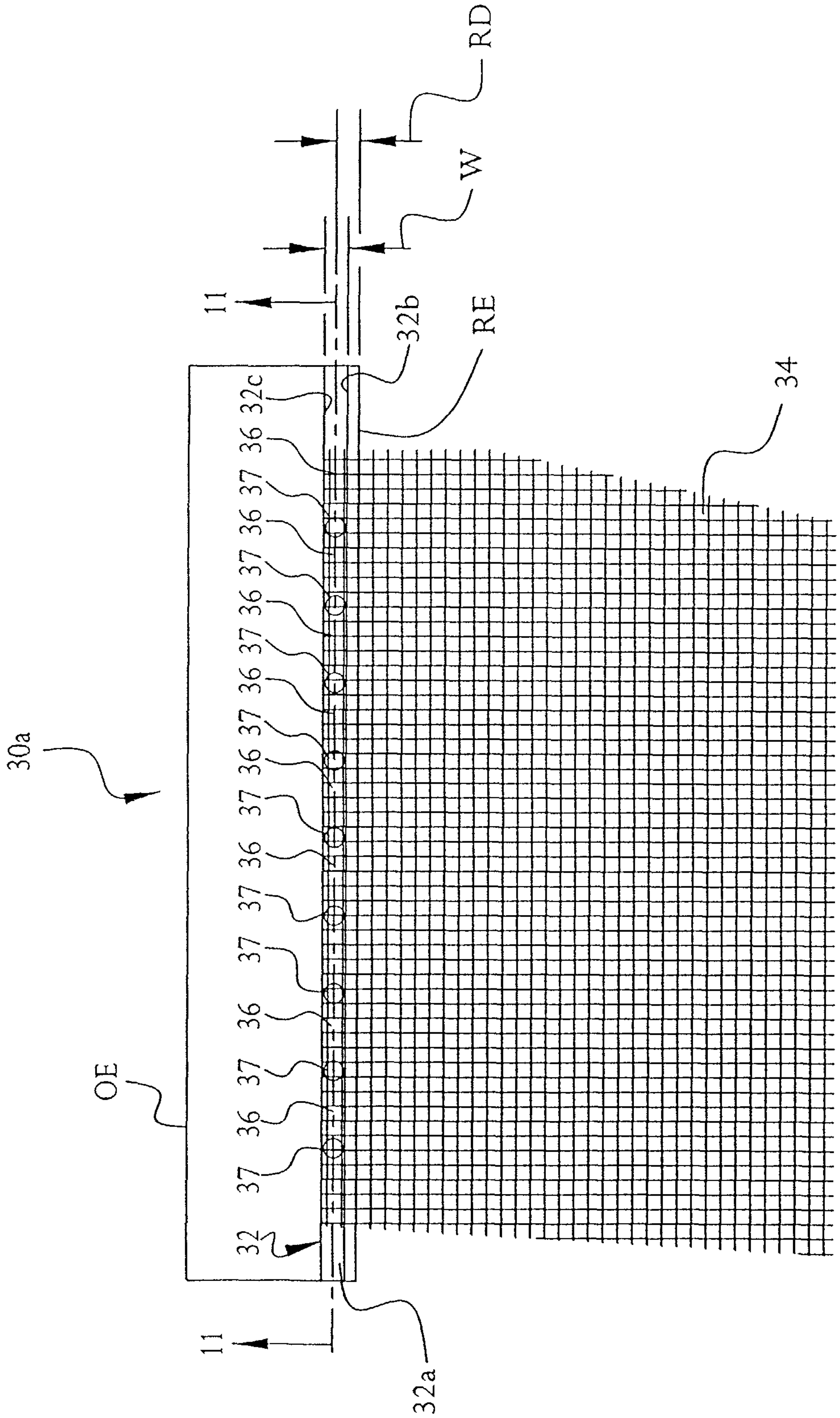


FIG. 10

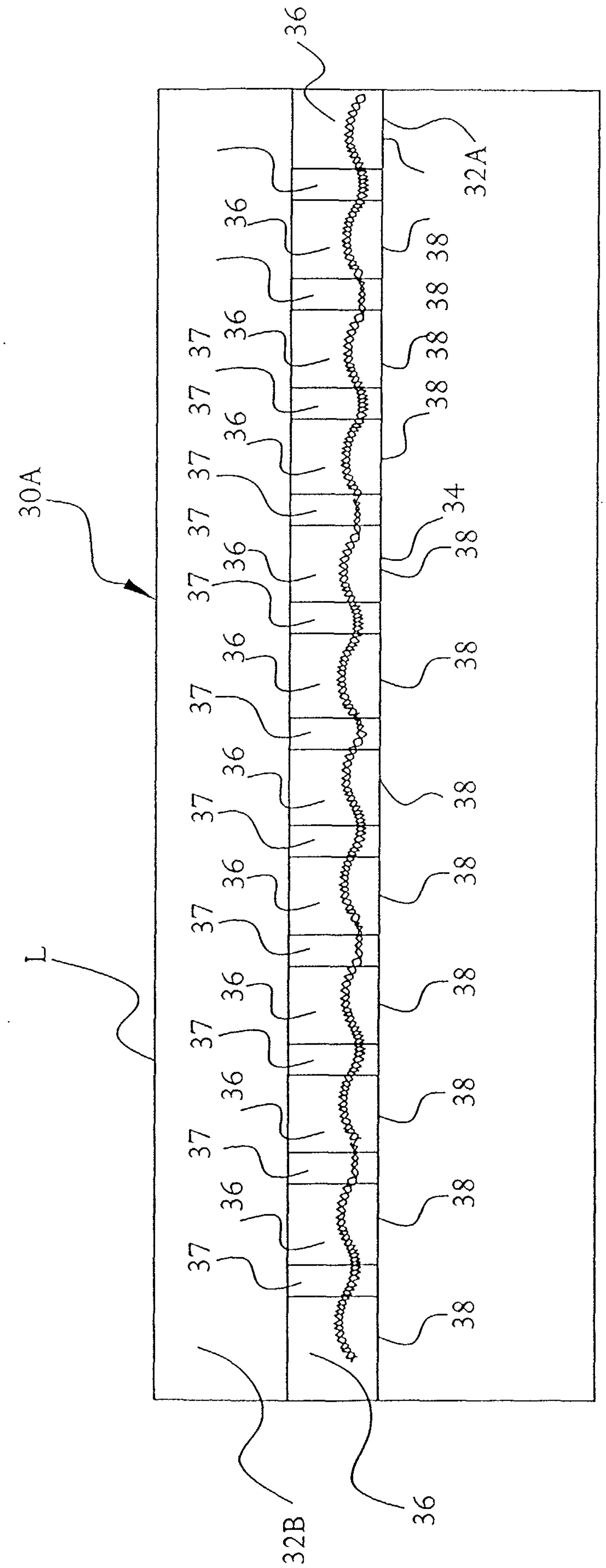


FIG. 11

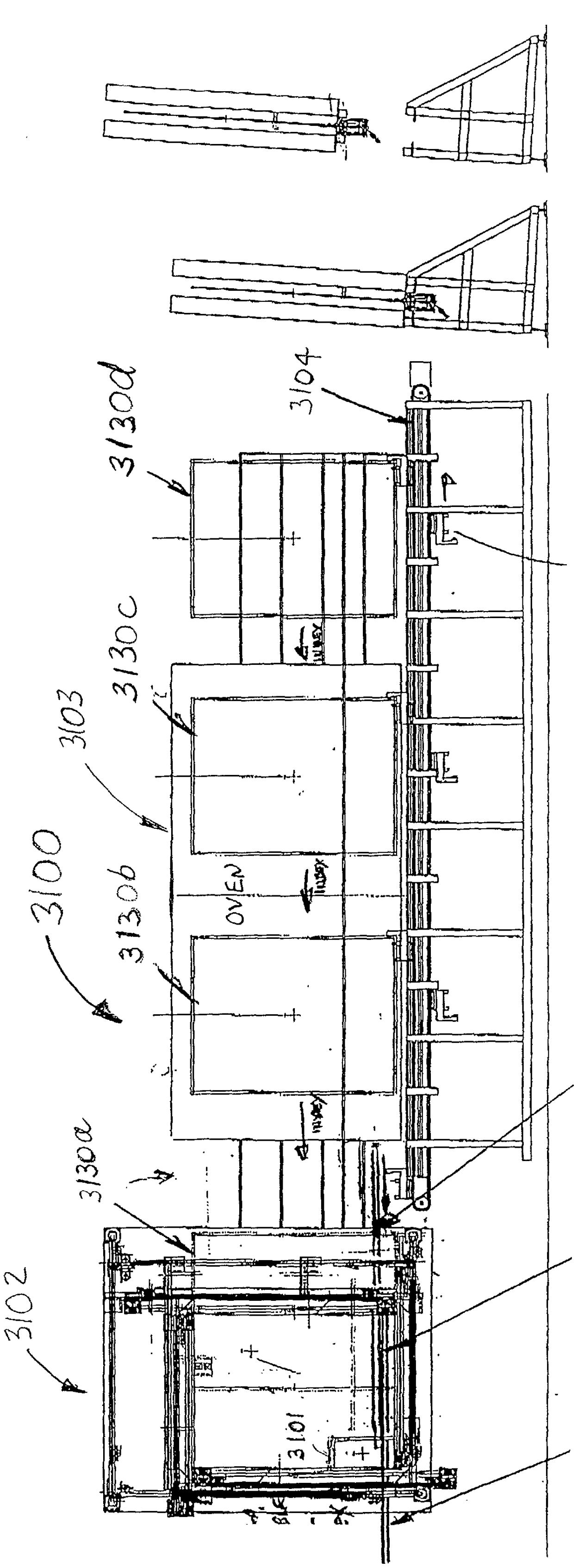


FIG. 12A

FIG. 12B

FIG. 12C

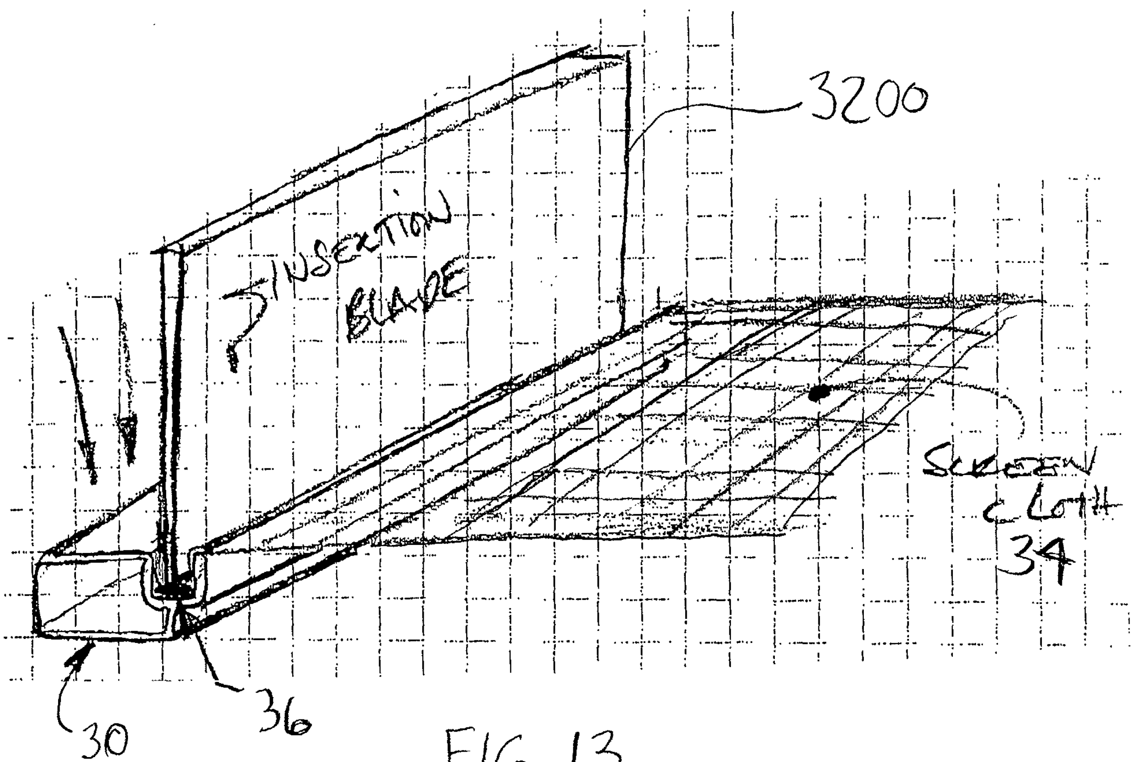
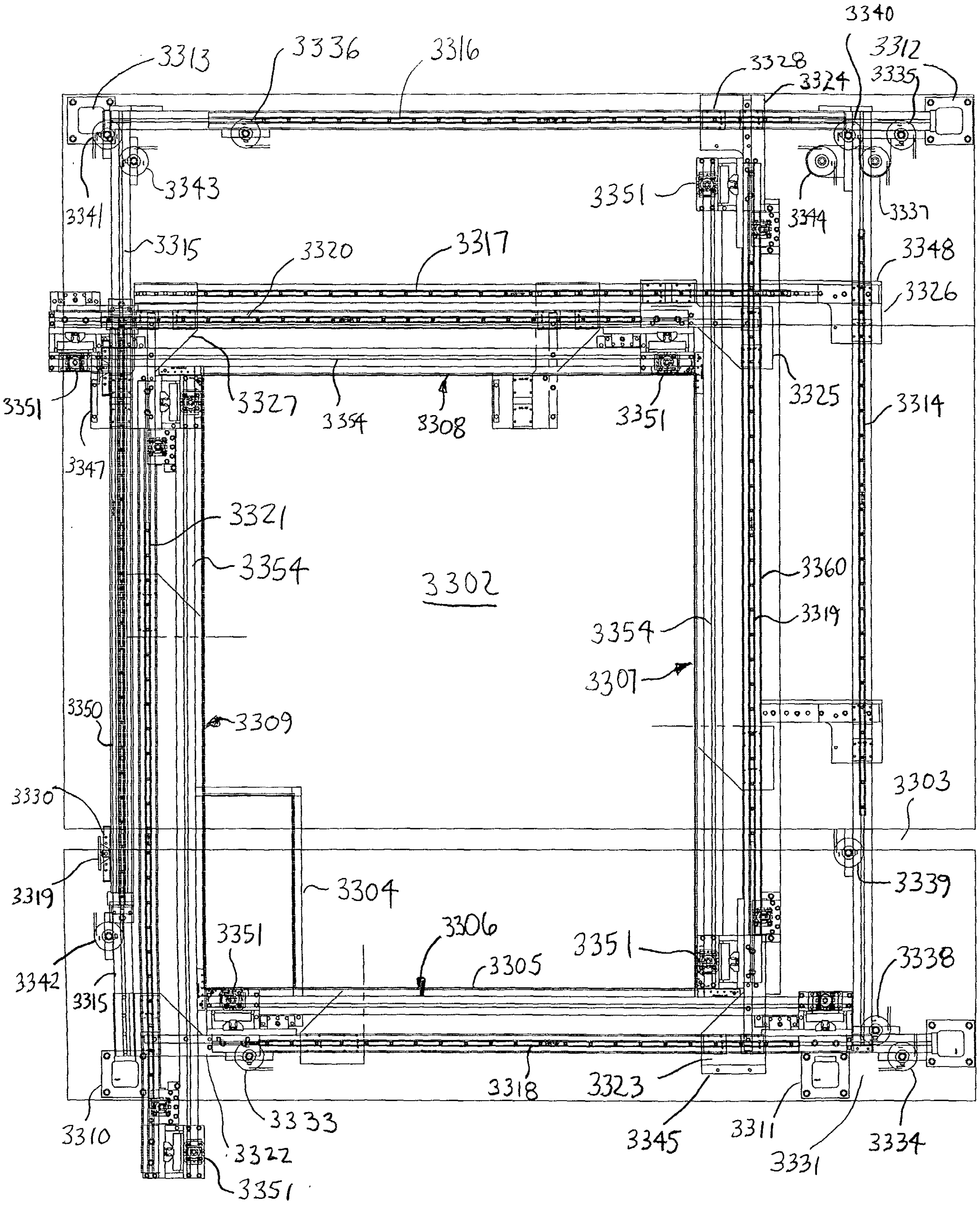


FIG. 13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3351
3306
3305
3351
3338
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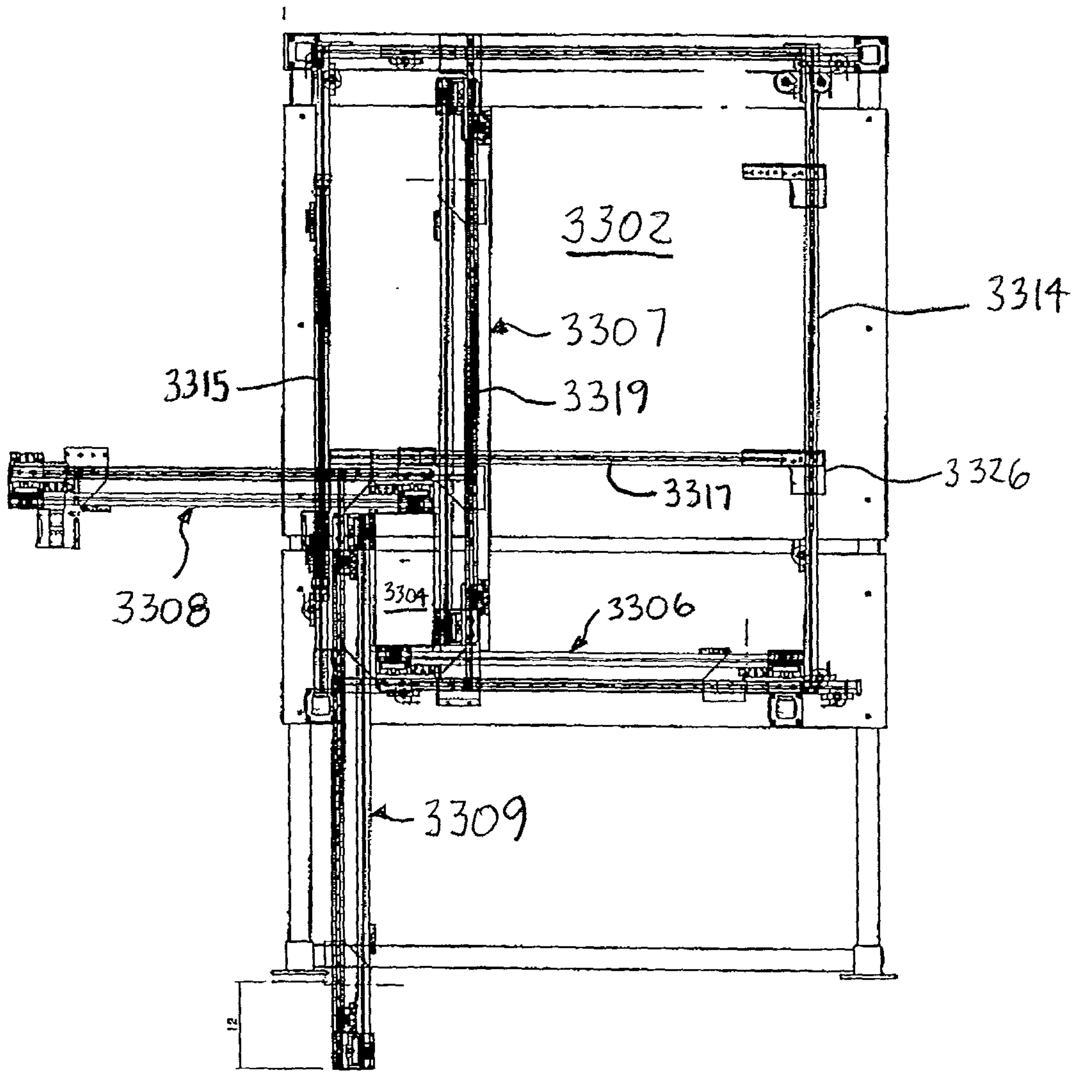
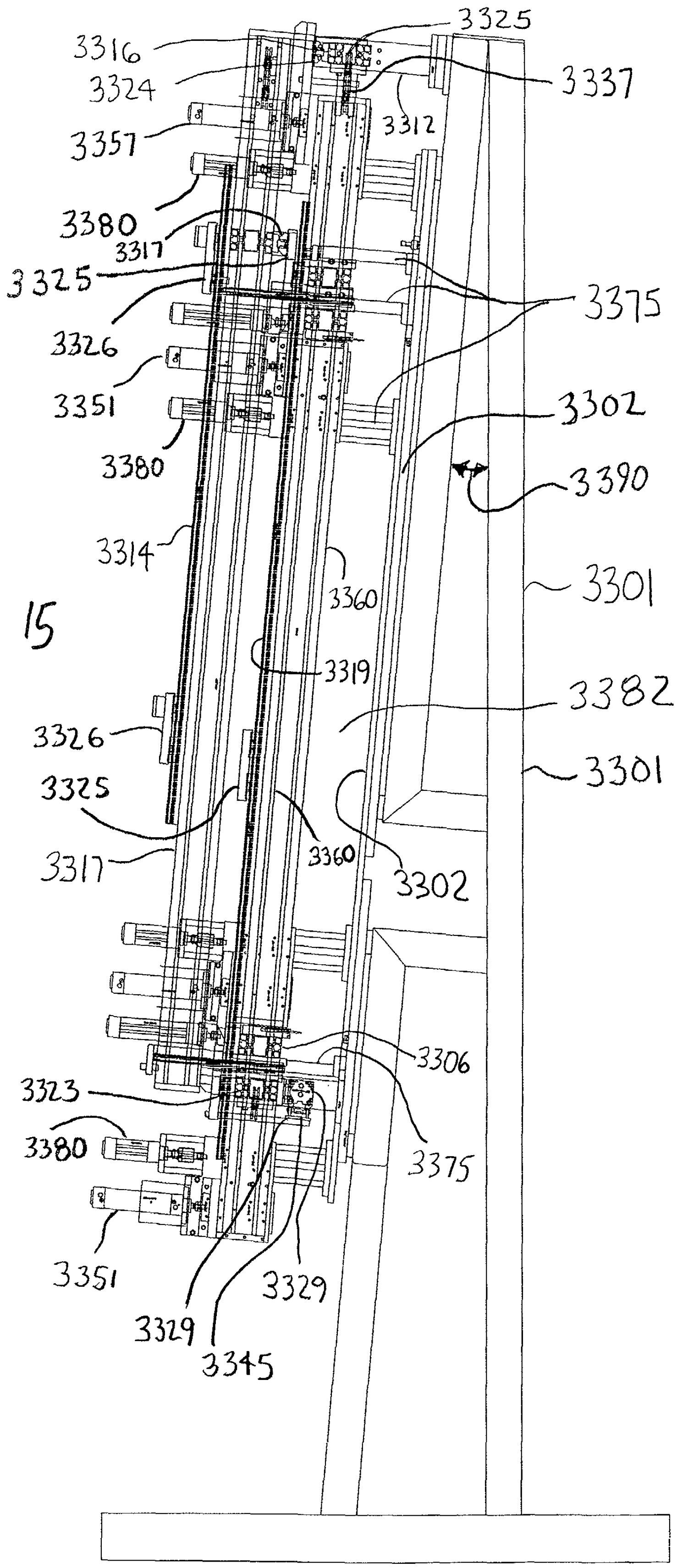
3334
3322
3351

FIG. 14A

FIG. 14B

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3319
3382
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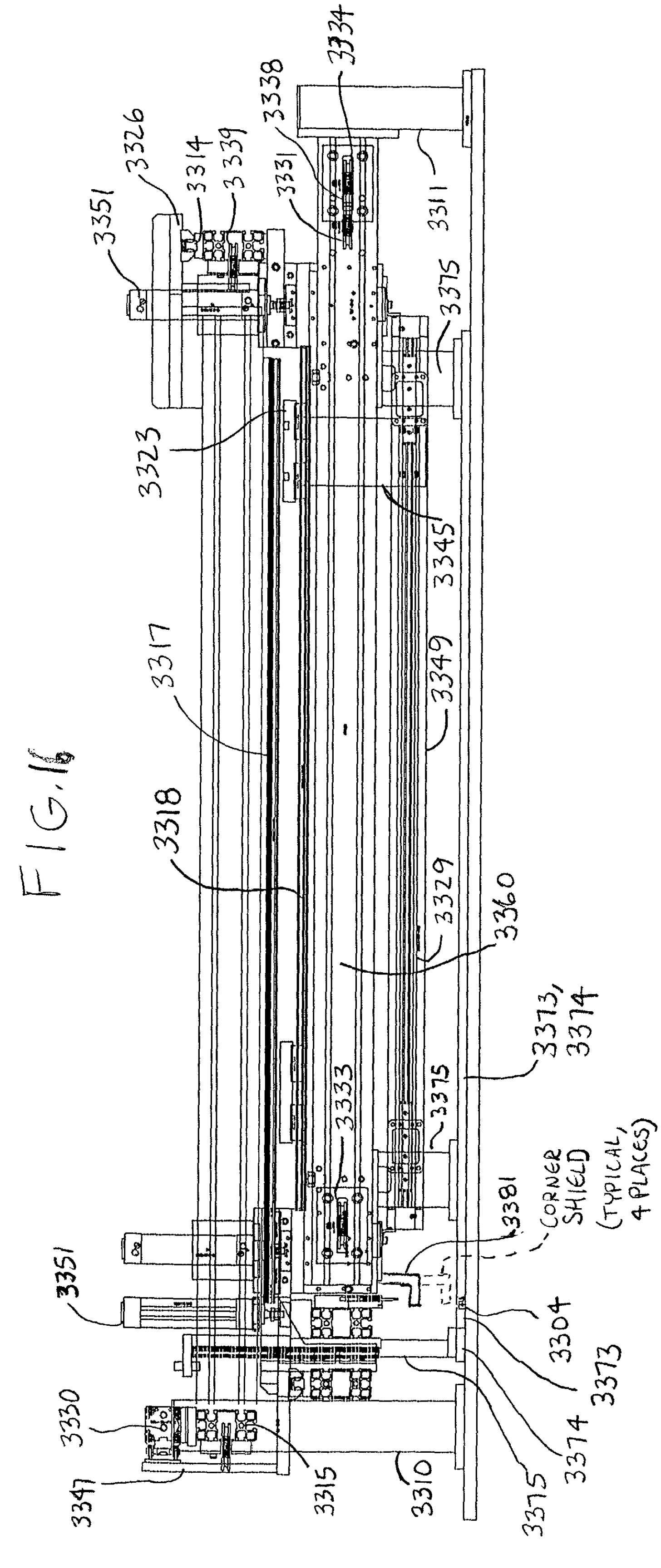
FIG. 15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3323
3345
3317
3349
3318
3329
3360
3373, 3374
3375
3333
CORNER SHIELD (TYPICAL, 4 PLACES)
3381
3304
3373
3374
3375
3310
3315
3330
3347
3351

FIG. 16

FIG. 17

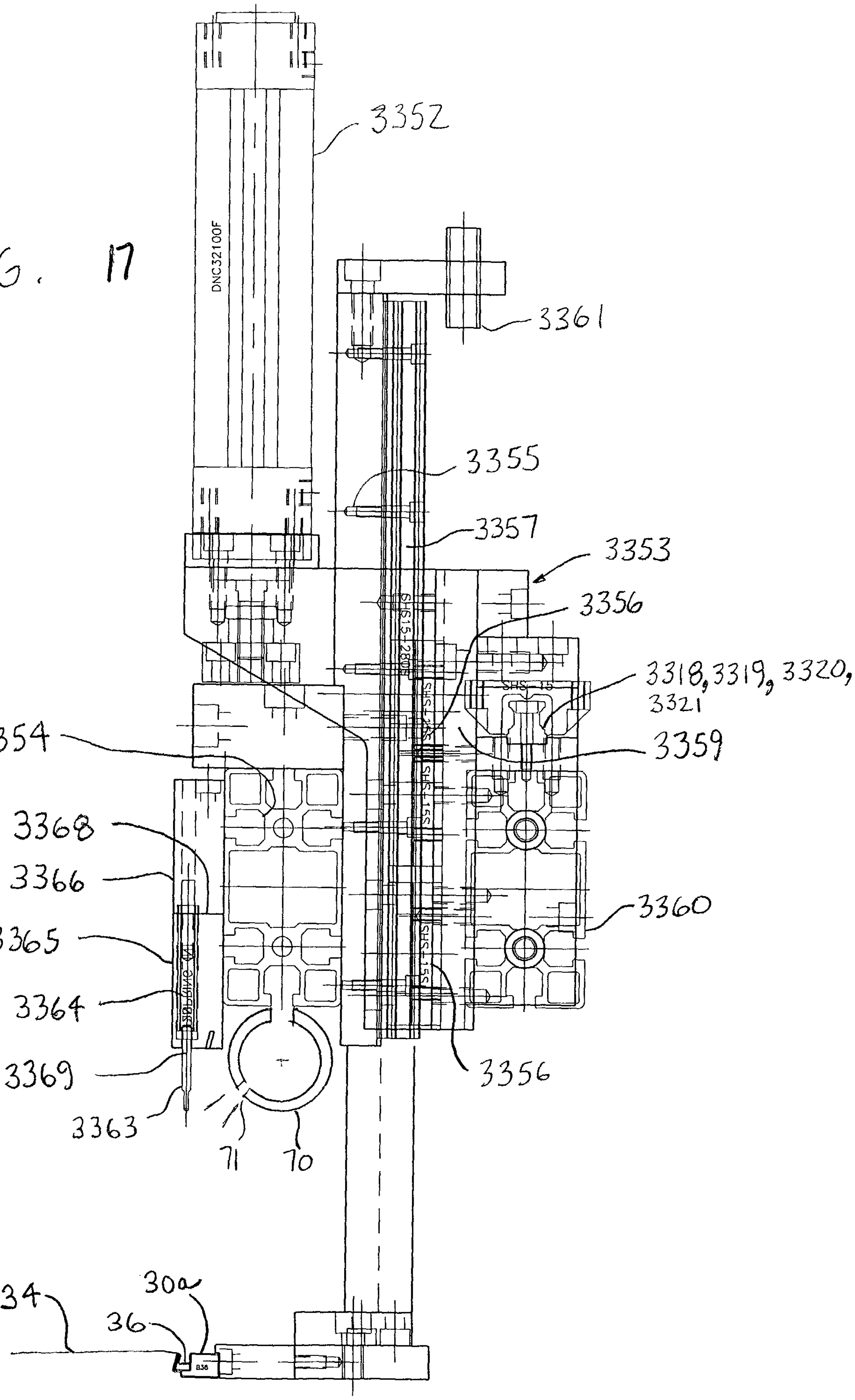
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FIG.18

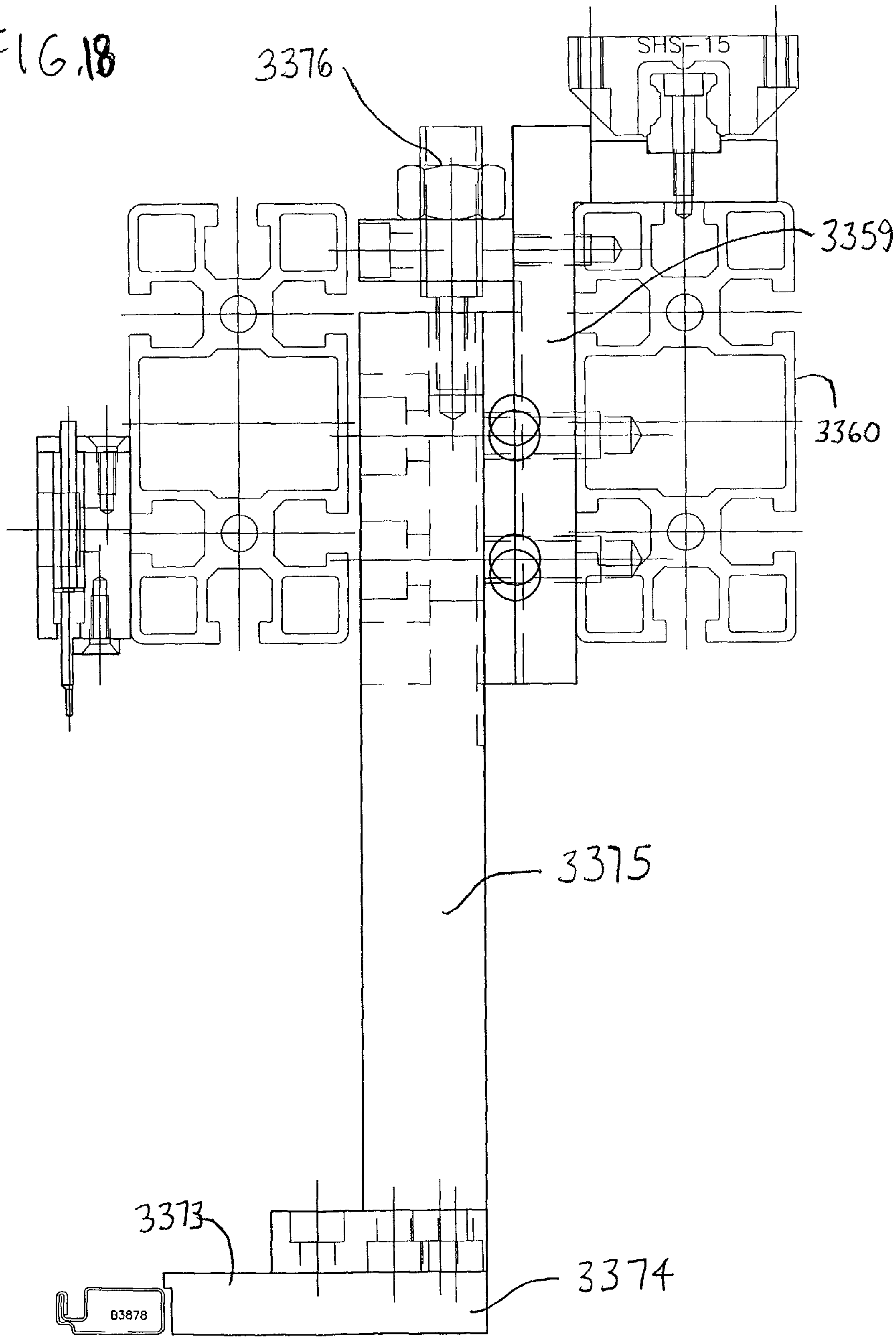
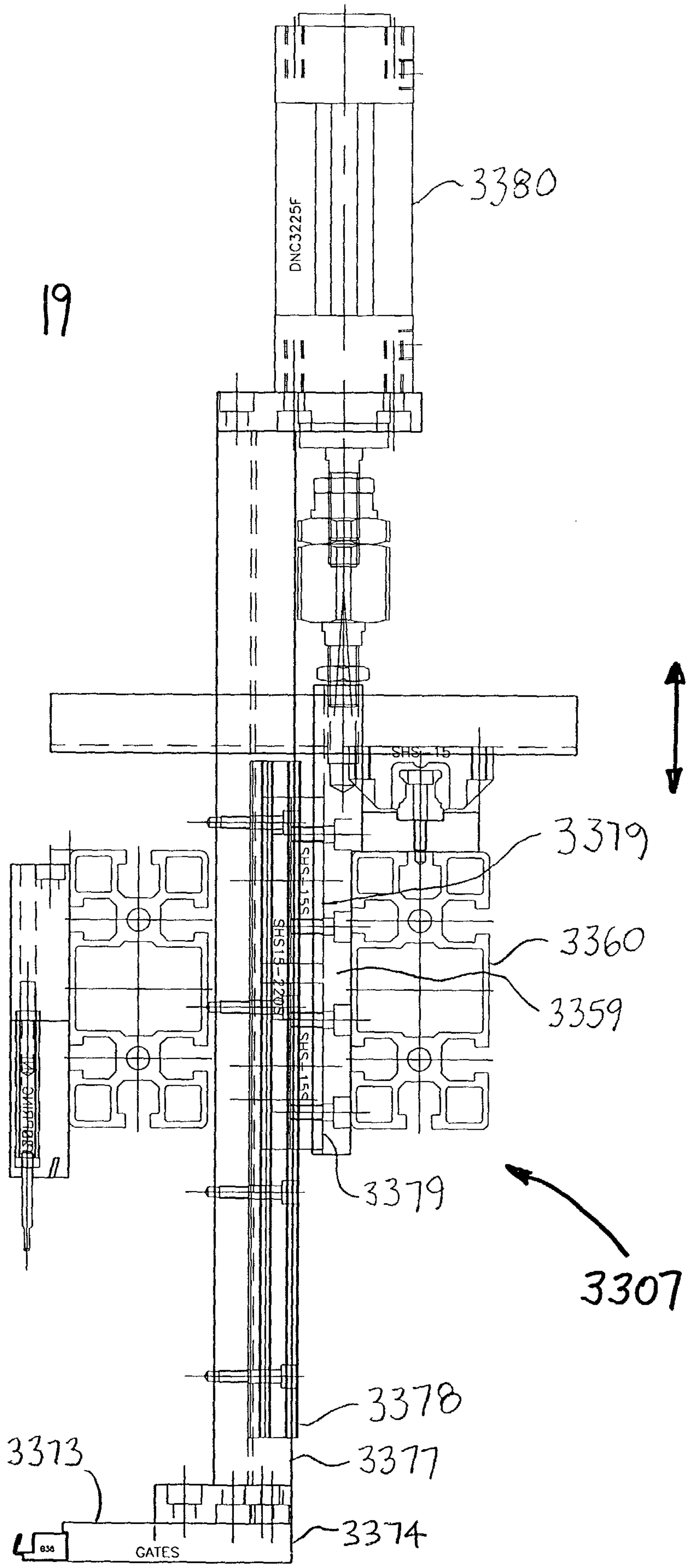


FIG. 19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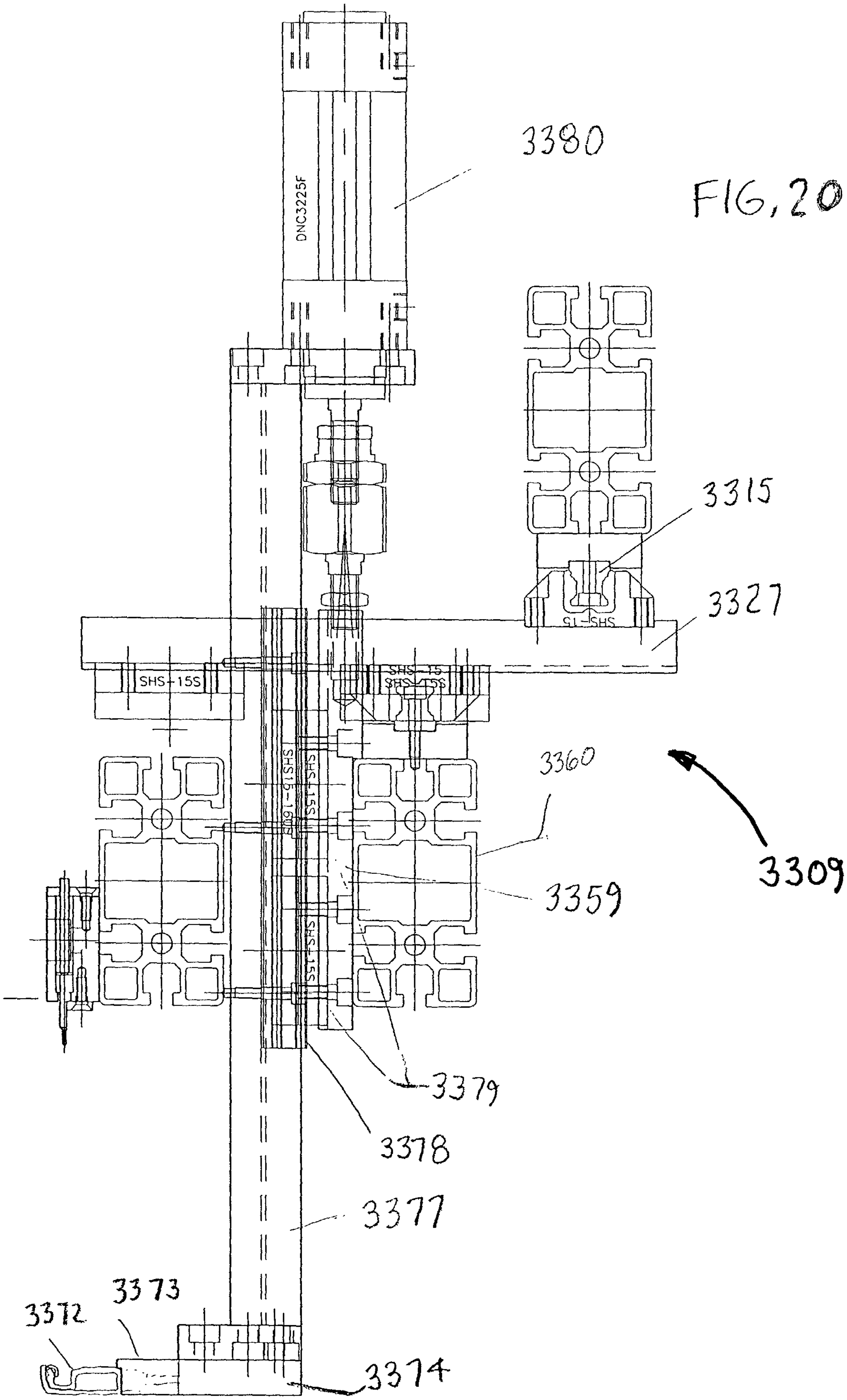
SHS-15
3379
3360
3359
SHS15-220S
SHS-15S
3379
3307
3378
3373
3377
3374
GATES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3327
SHS-15
SHS-15S
SHS15-160S
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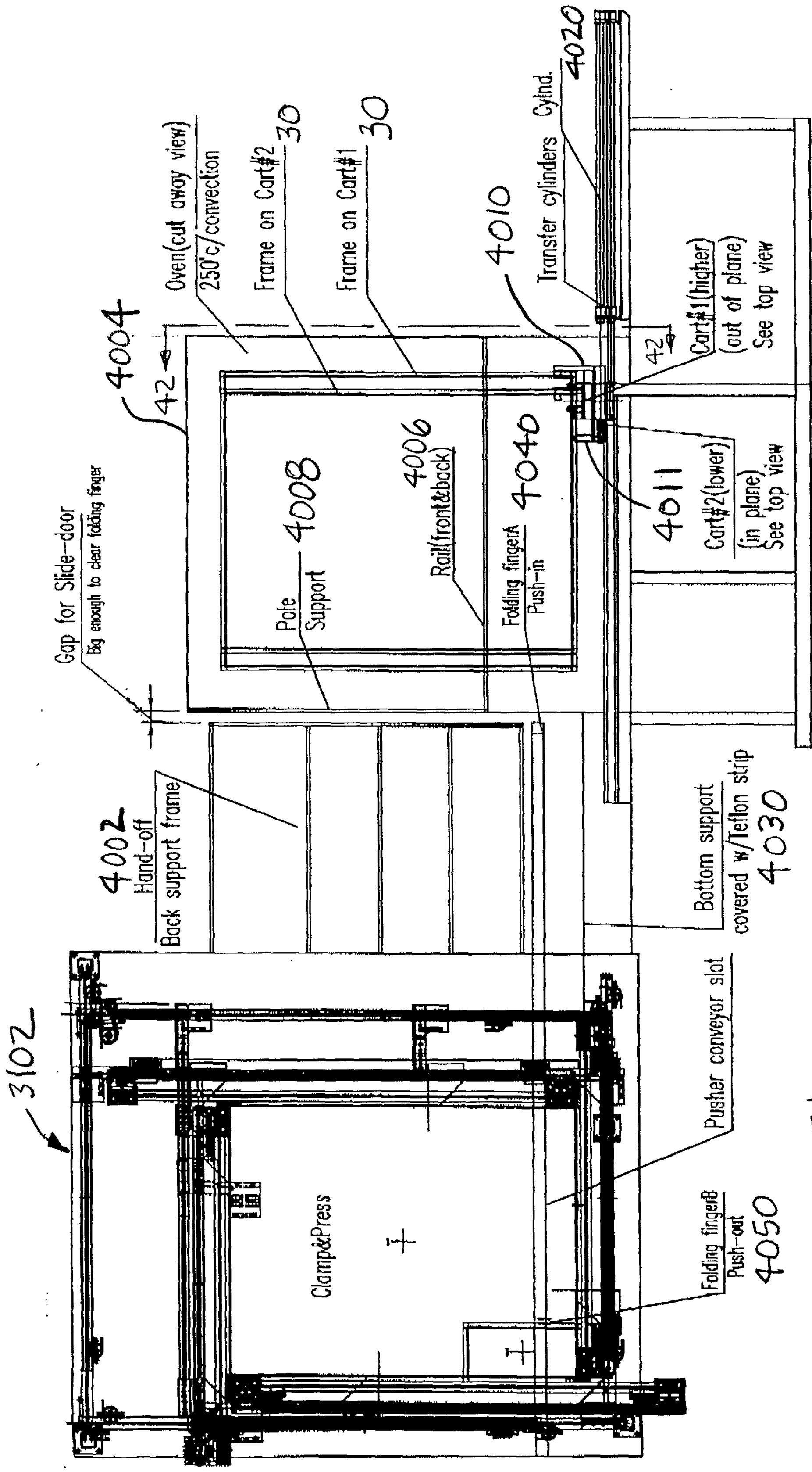
3359
3309
3379
3378
3377
3373
3372
3374

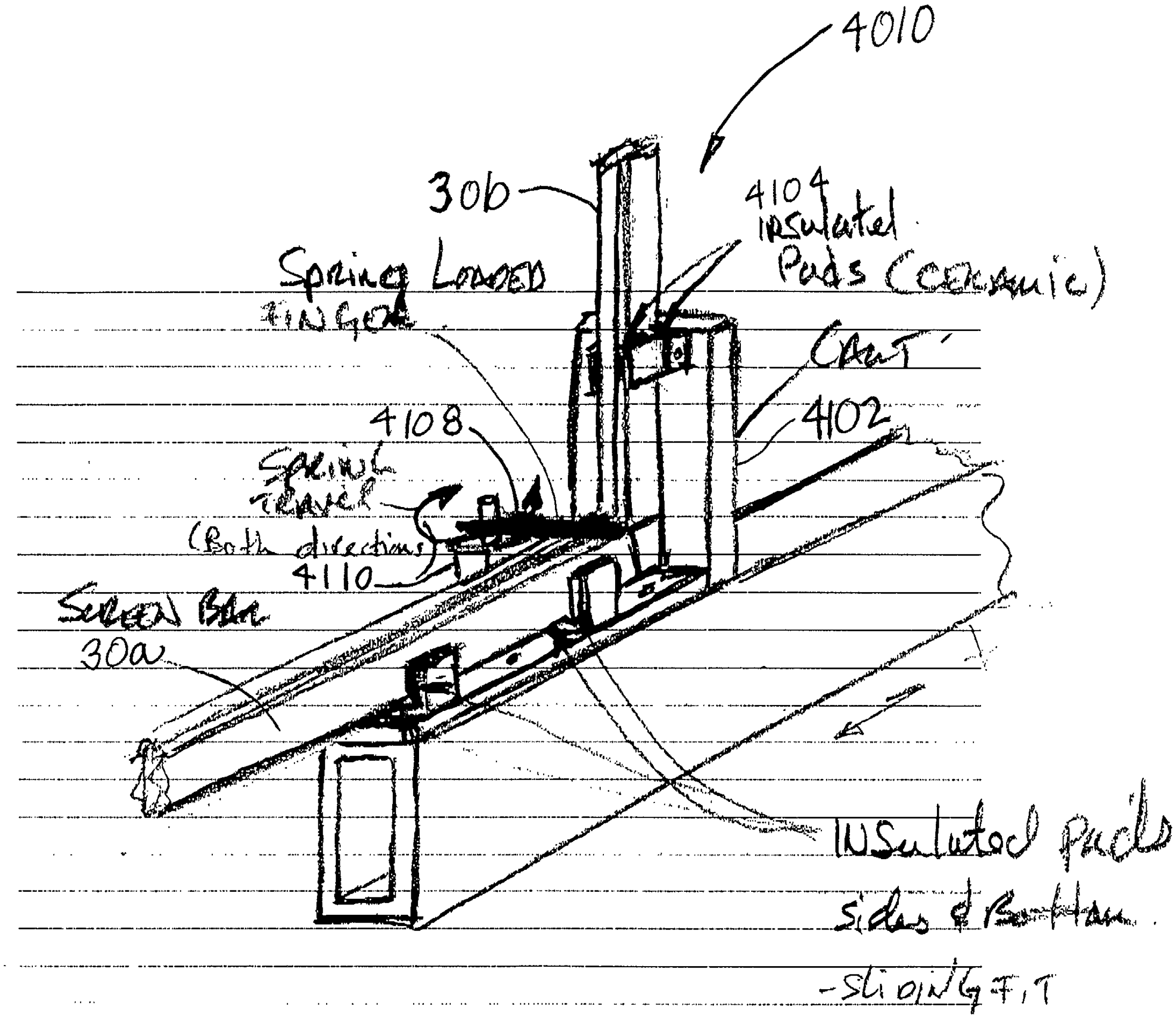
FIG. 20



Elevation view- "Both frames in oven"

FIG. 21

Note:
Carts are offset in both dimention
to make clearance to pass each other.



4010
30b
4104
Insulated Pads (Ceramic)
Spring Loaded Finger
Cart
4108
4102
Spring Travel
(Both directions)
4110
Screen Bar
30a
Insulated pads
Sides & Bottom
-Sliding Fit

FIG. 22

FIG. 24

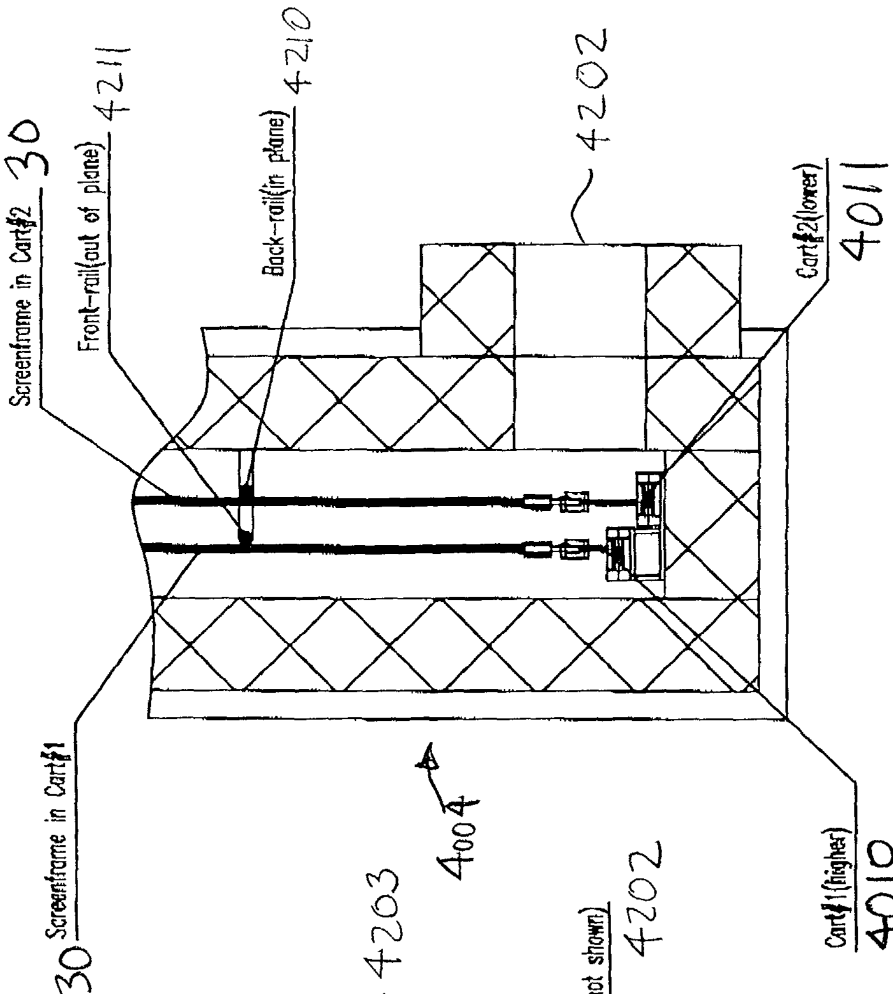
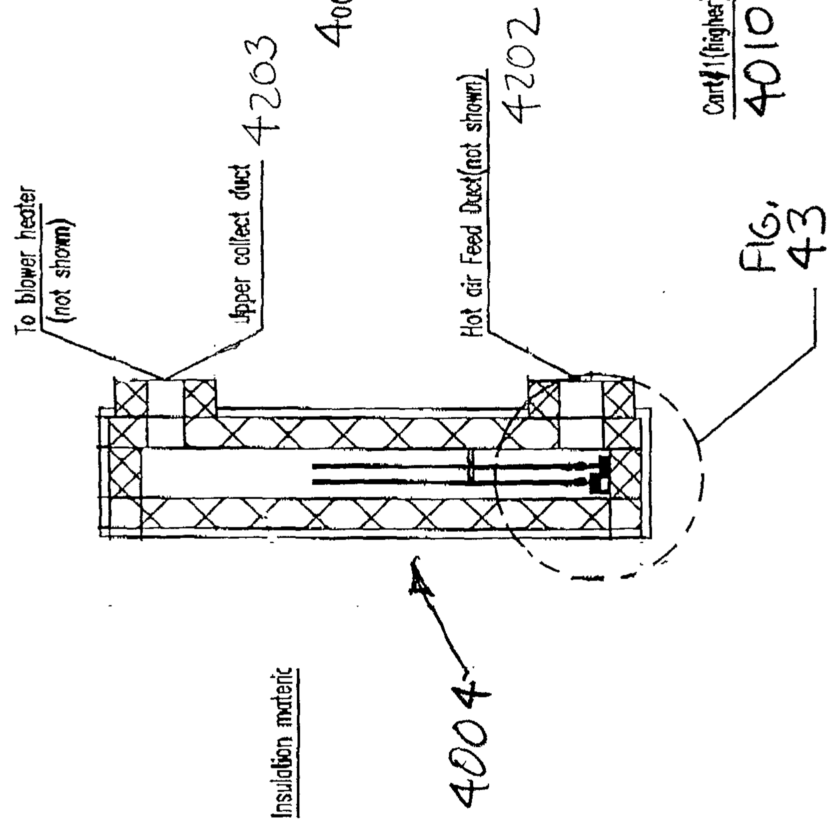

Screenframe in Cart#2 30
Front-rail(out of plane) 4211
Back-rail(in plane) 4210
4202
Cart#2(lower) 4011
4004
30 Screenframe in Cart#1
Cart#1(higher) 4010

FIG. 23


To blower heater (not shown)
Upper collect duct 4203
Hot air Feed Duct(not shown) 4202
FIG. 43
4004
Insulation materic

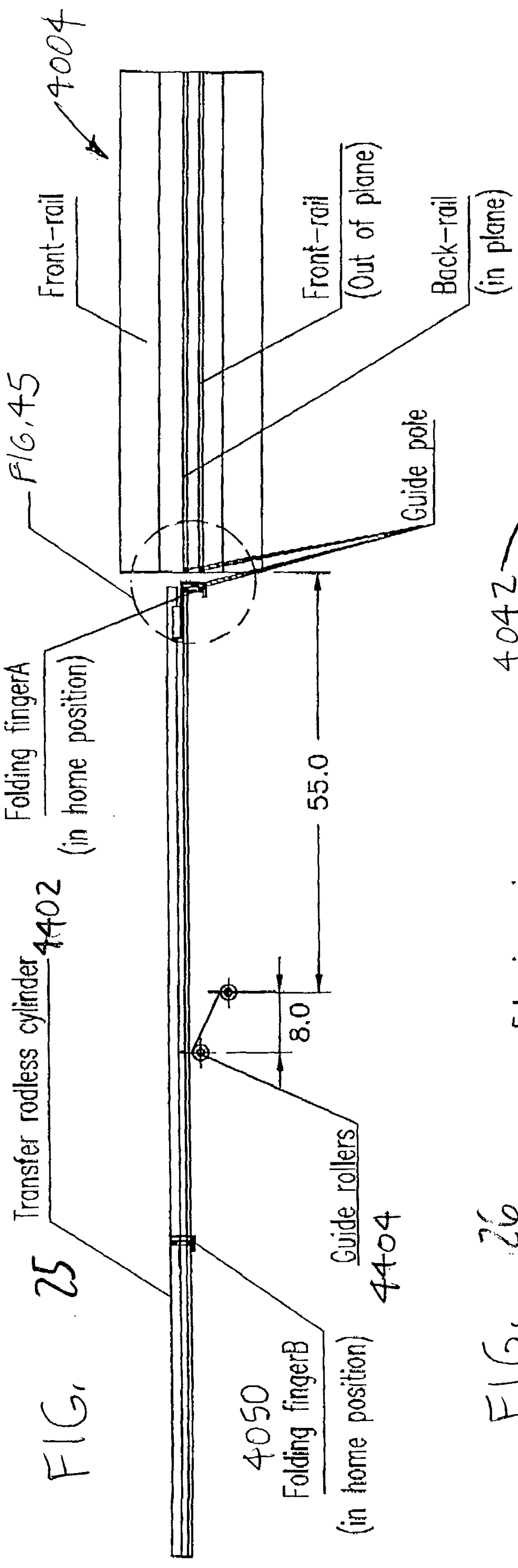


FIG. 25

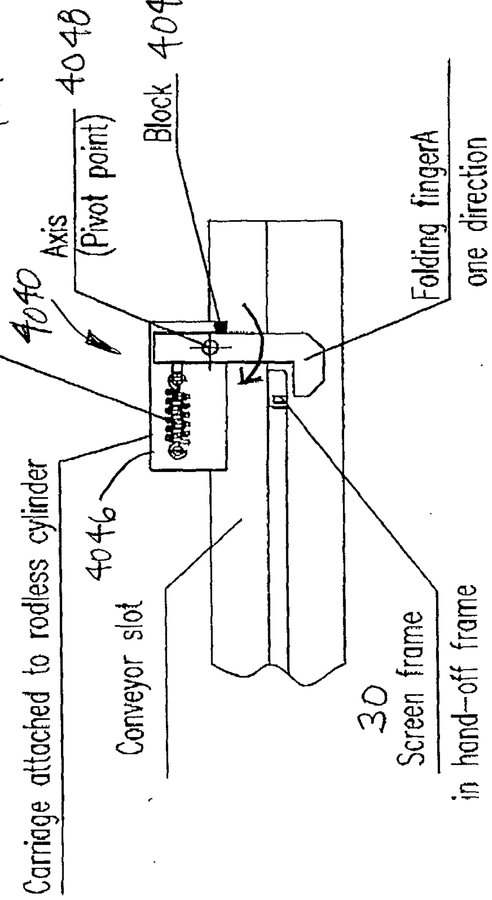


FIG. 26

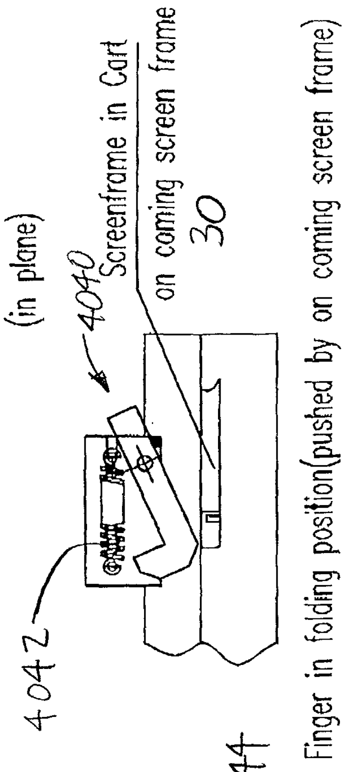


FIG. 27

FIG. 29

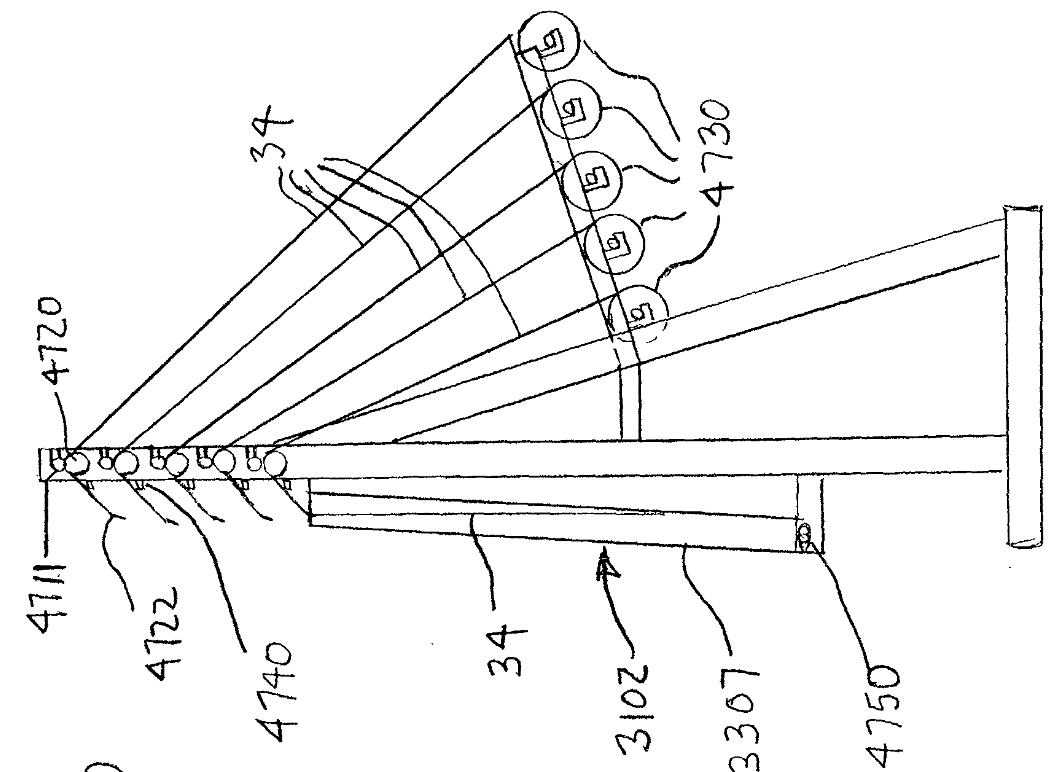


FIG. 28