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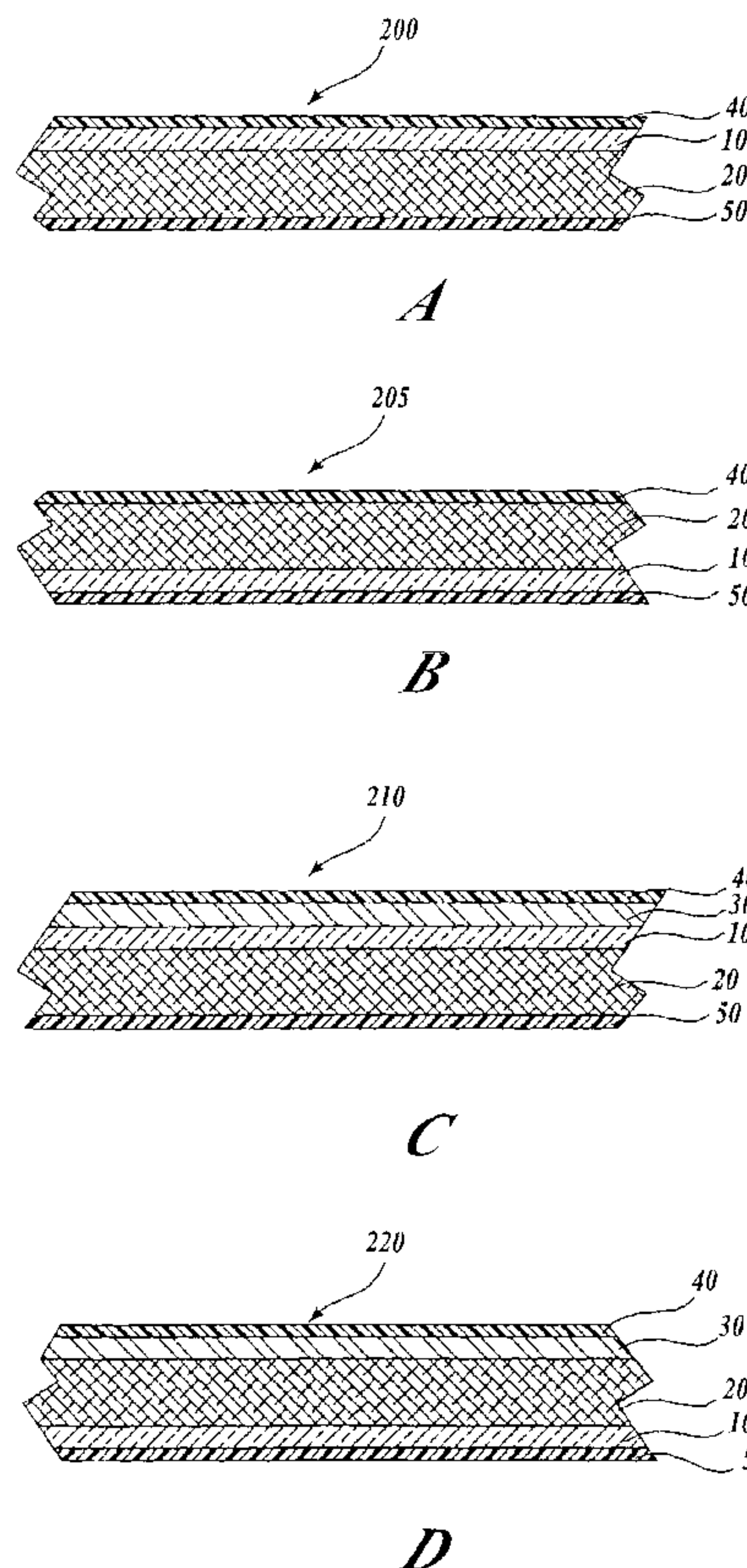
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(54) Titre : COUCHE DE DISTRIBUTION AMELIORANT LE TRANSFERT DE LIQUIDE JUSQU'A UNE COUCHE
D'ACCUMULATION

(54) Title: DISTRIBUTION LAYER HAVING IMPROVED LIQUID TRANSFER TO A STORAGE LAYER



(57) Abrégé/Abstract:

A fibrous layer that includes a refined blend of crosslinked cellulosic fibers and noncrosslinked cellulosic fibers. In one embodiment, the layer includes about 85 percent by weight crosslinked fibers and about 15 percent by weight noncrosslinked fibers. An absorbent construct that includes the fibrous layer and a liquid storage layer. Personal care absorbent products that include the distribution layer.

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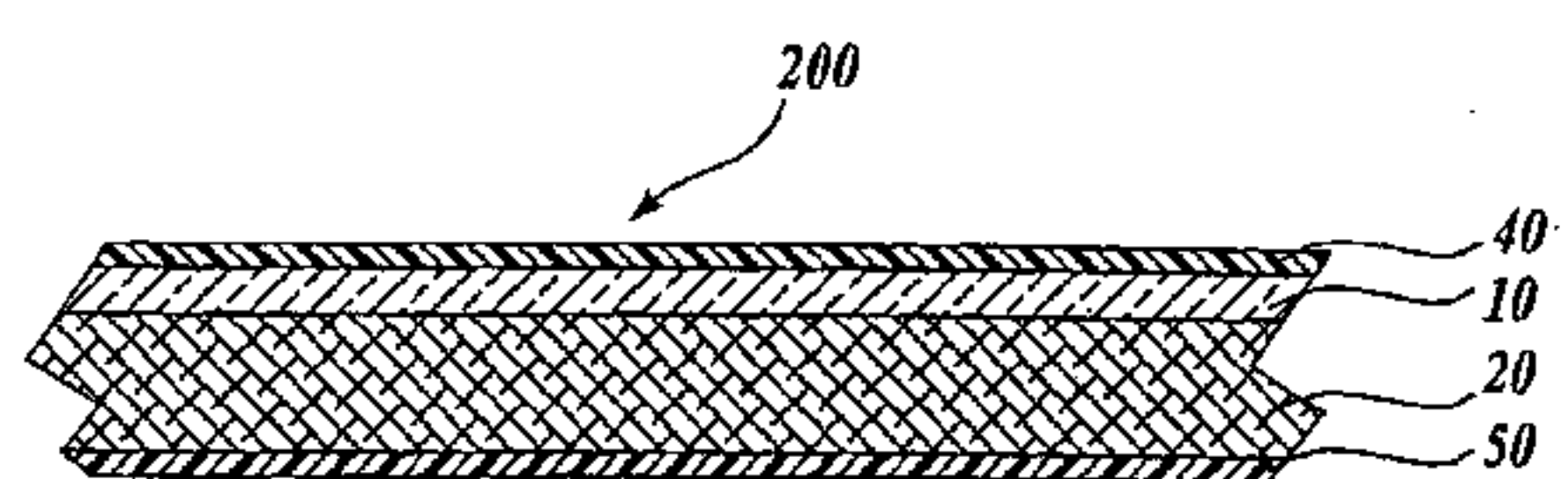
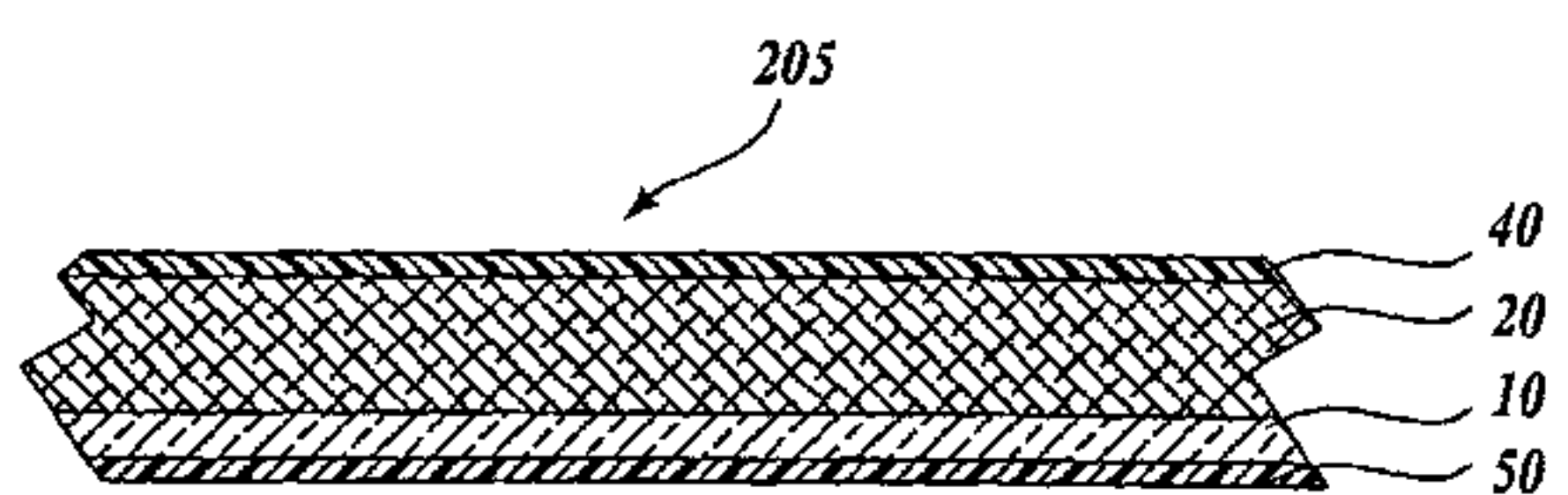
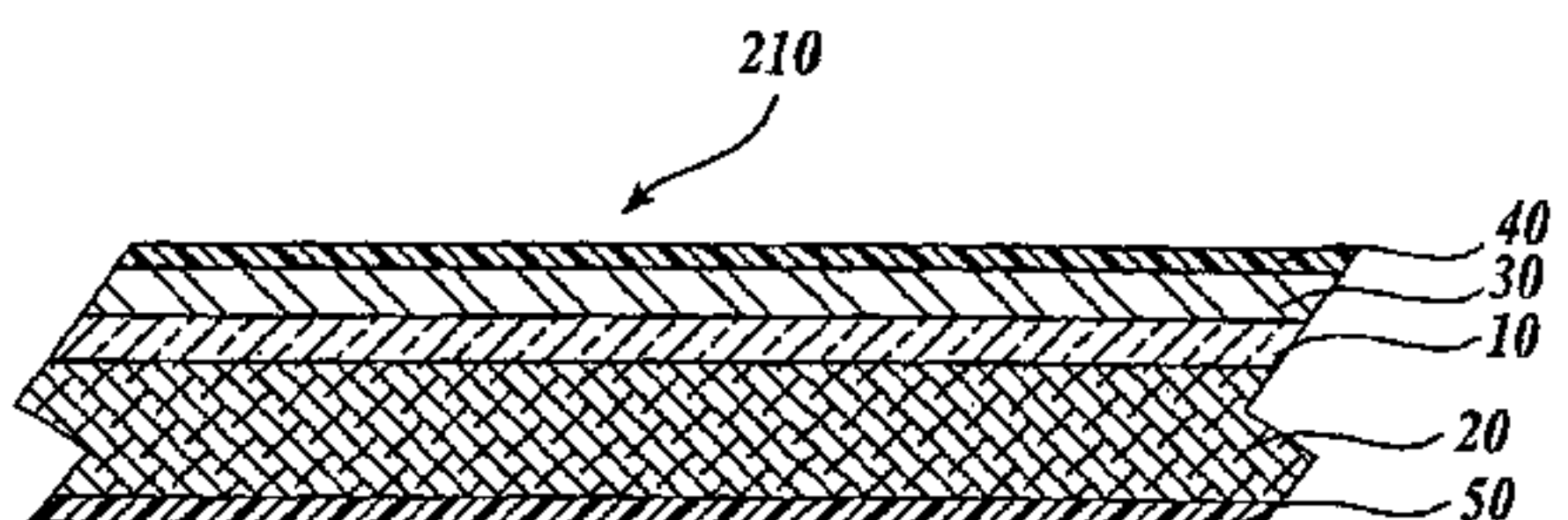
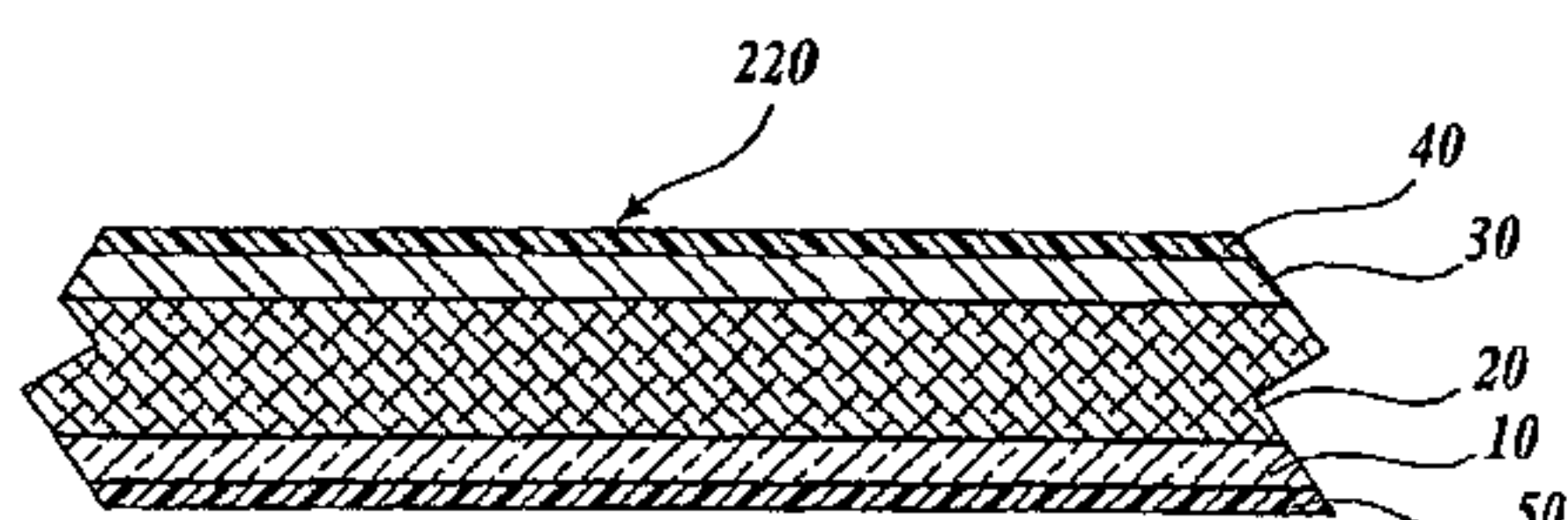
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(54) Title: DISTRIBUTION LAYER HAVING IMPROVED LIQUID TRANSFER TO A STORAGE LAYER

**A****B****C****D**

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DISTRIBUTION LAYER HAVING IMPROVED LIQUID TRANSFER TO A STORAGE LAYER

FIELD OF THE INVENTION

The present invention relates to an cellulosic fibrous layer for distributing acquired liquid to a storage layer in liquid communication therewith.

BACKGROUND OF THE INVENTION

Personal care absorbent products, for example, infant diapers, adult incontinence products, and feminine care products, can include liquid acquisition and/or distribution layers that serve to rapidly acquire and then distribute acquired liquid to a storage core for retention. To achieve rapid acquisition and distribution, these layers often include cellulosic fibers. These layers can include crosslinked cellulosic fibers to impart bulk and resilience to the layer, and wood pulp fibers to increase the wicking of liquid within the layer and to facilitate distribution of the liquid throughout the layer and ultimately to another layer, such as a storage layer, that is in liquid communication with the distribution layer. However, despite advances in these layers, the need exists for a more efficient liquid distribution layer that effectively distributes and transfers acquired liquid to an associated storage layer. The present invention seeks to fulfill these needs and provides further related advantages.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides a fibrous layer that includes a refined blend of crosslinked cellulosic fibers and noncrosslinked cellulosic fibers. In one embodiment, the layer includes about 85 percent by weight crosslinked fibers and about 15 percent by weight noncrosslinked fibers.

In another aspect of the invention, an absorbent construct is provided that includes a liquid distribution layer and a liquid storage layer. The distribution layer includes a refined blend of crosslinked cellulosic fibers and noncrosslinked cellulosic fibers.

In other aspects, the invention provides personal care absorbent products that include the distribution layer, and methods for making the distribution layer.

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BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a schematic diagram of a representative twin-wire forming device and method for making a representative layer of the invention;

FIGURE 2 is a schematic diagram of a representative twin-wire forming device and method for making a representative layer of the invention;

FIGURE 3 is a graph of wick time, dry tensile, and cantilever stiffness for a representative layer of the invention;

FIGURE 4 is a graph of comparing fluid transfer for three representative layers of the invention to a storage layer as a function of time;

FIGURE 5 is a bar graph comparing the fourth gush acquisition time for absorbent constructs: control training pant; control pant and representative layer of the invention; control pant with a storage core; and control pant, representative layer of the invention and storage core;

FIGURE 6 is a bar graph comparing the overall liquid capacity before leakage for absorbent constructs: control training pant; control pant and representative layer of the invention; control pant with a storage core; and control pant, representative layer of the invention and storage core;

FIGURE 7 illustrates the distribution of liquid in a training pant: control training pant; control pant and representative layer of the invention having a basis weight of about 90 gsm; and control pant and representative layer of the invention having a basis weight of about 180 gsm;

FIGURE 8 illustrates the distribution of liquid in a training pant: control training pant; control pant with a storage core; control pant, storage layer, and representative layer of the invention having a basis weight of about 90 gsm; and control pant, storage layer, and representative layer of the invention having a basis weight of about 180 gsm

FIGURE 9 is a bar graph comparing the third gush acquisition rate for absorbent constructs: control training pant; control pant and representative layer of the invention;

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control pant with a storage core; and control pant, representative layer of the invention and storage core;

FIGURE 10 is a graph comparing acquisition rate as a function of insult number for absorbent constructs: control training pant; control pant and representative layer of the invention; control pant with a storage core; and control pant, representative layer of the invention and storage core;

FIGURE 11 is a bar graph comparing the fourth gush rewet for absorbent constructs: control training pant; control pant and representative layer of the invention; control pant with a storage core; and control pant, representative layer of the invention and storage core;

FIGURES 12A-C illustrate cross-sectional views of portions of representative absorbent constructs that include the distribution layer of the invention;

FIGURE 13A-D illustrate cross-sectional views of portions of representative absorbent articles that include the distribution layer of the invention;

FIGURES 14A-E illustrate an apparatus for determining pressurized vertical wicking values;

FIGURE 15 is a table summarizing the characteristics of absorbent constructs including a distribution layer of the invention;

FIGURE 16 is a table summarizing the characteristics of absorbent constructs including a distribution layer of the invention;

FIGURE 17 is a table summarizing the characteristics of absorbent constructs including a distribution layer of the invention;

FIGURE 18 is a table summarizing the characteristics of absorbent constructs including a distribution layer of the invention; and

FIGURE 19 is a table summarizing the characteristics of absorbent constructs including a distribution layer of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In one aspect, the present invention provides a cellulosic fibrous layer that distributes and transfers liquid acquired by the layer to a storage layer that is in liquid communication therewith. The cellulosic fibrous layer of the invention is a distribution layer that can be incorporated into a personal care absorbent product such as an infant

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diaper, adult incontinent product, or a feminine care product, among others. In a personal care absorbent product, the distribution layer can be used in combination with one or more other layers. Other layers can include, for example, a storage layer for receiving and storing liquid transferred from the distribution layer, or a storage layer and an acquisition layer.

The distribution layer of the invention includes cellulosic fibers. The cellulosic fibers are suitably wood pulp fibers. In one embodiment, the layer includes a combination of crosslinked cellulosic fibers and noncrosslinked cellulosic fibers.

The distribution layer's crosslinked cellulosic fibers impart bulk and resilience to the layer and provide the layer with a generally open structure for distributing liquid. Suitable crosslinked cellulosic fibers include chemically intrafiber crosslinked cellulosic fibers and are described below. The layer includes crosslinked cellulosic fibers in an amount from about 50 to about 90 percent by weight based on the total weight of fibers in the layer. In one embodiment, the layer includes crosslinked cellulosic fibers in an amount from about 75 to about 90 percent by weight based on the total weight of fibers in the layer. In another embodiment, the layer includes about 85 percent by weight crosslinked cellulosic fibers based on the total weight of fibers in the layer. The layer can include refined crosslinked fibers. The layer can include a refined blend of crosslinked and noncrosslinked fibers.

The distribution layer's noncrosslinked fibers enhance the layer's liquid wicking performance. Suitable noncrosslinked cellulosic fibers include wood pulp fibers capable of liquid wicking and are described below. The layer includes noncrosslinked cellulosic fibers in an amount from about 10 to about 50 percent by weight based on the total weight of fibers in the layer. In one embodiment, the layer includes noncrosslinked cellulosic fibers in an amount from about 10 to about 25 percent by weight based on the total weight of fibers in the layer. In another embodiment, the layer includes about 15 percent by weight noncrosslinked cellulosic fibers based on the total weight of fibers in the layer. The noncrosslinked fibers can include softwood fibers (e.g., southern pine fibers) and hardwood fibers (e.g., Westvaco hardwood fibers or eucalyptus fibers).

In one embodiment, the layer includes southern pine pulp fibers commercially available from Weyerhaeuser Company under the designation NB416. In another

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embodiment, the layer includes southern pine pulp fibers that have been refined. In a further embodiment, the layer includes eucalyptus pulp fibers. In another embodiment, the layer includes a blend of southern pine and eucalyptus fibers. In still another embodiment, the layer includes a blend of eucalyptus fibers and refined southern pine fibers. In yet a further embodiment, the layer includes a refined blend of southern pine and eucalyptus fibers.

For embodiments that include blends of southern pine and eucalyptus fibers, the ratio of southern pine fibers to eucalyptus fibers can range from about 0.5 to about 1.0 to about 1.0 to about 0.5. In one embodiment, the layer includes about 8 percent by weight eucalyptus fibers, about 7 percent by weight southern pine fibers, and about 85 percent by weight crosslinked fibers based on the total weight of fibers in the layer. In another embodiment, the layer includes about 8 percent by weight eucalyptus fibers, about 7 percent by weight refined southern pine fibers, and about 85 percent by weight crosslinked fibers based on the total weight of fibers in the layer. In another embodiment, the layer includes a refined blend of eucalyptus and southern pine fibers, the layer including about 8 percent by weight eucalyptus fibers, about 7 percent by weight southern pine fibers, and about 85 percent by weight crosslinked fibers based on the total weight of fibers in the layer. In yet another embodiment, the layer includes a refined blend of eucalyptus, southern pine, and crosslinked fibers, the layer including about 8 percent by weight eucalyptus fibers, about 7 percent by weight southern pine fibers, and about 85 percent by weight crosslinked fibers based on the total weight of fibers in the layer.

In one embodiment, the distribution layer includes about 85 percent by weight crosslinked fibers, from about 5 to about 15 percent by weight refined southern pine fibers having a Canadian Standard Freeness of about 500, and from about 0 to about 10 percent by weight southern pine fibers. In one embodiment, the crosslinked fibers, refined southern pine fibers, and southern pine fibers are refined as a blend prior to layer formation.

In another embodiment, the distribution layer includes about 85 percent by weight crosslinked fibers, from about 3 to about 5 percent by weight hardwood fibers, and from about 10 to about 12 percent by weight southern pine fibers. In one embodiment, the

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crosslinked fibers, hardwood fibers, and southern pine fibers are refined as a blend prior to layer formation.

In one embodiment, the distribution layer has a basis weight in the range from about 20 to about 200 g/m². In another embodiment, the distribution layer has a basis weight in the range from about 50 to about 180 g/m². The distribution layer has a density in the range from about 0.1 to about 0.2 g/cm³.

The characteristics of four representative distribution layers are summarized in Tables 1 and 2 below. In Tables 1 and 2, unsoftened Layer A includes a refined blend of crosslinked fibers (85 percent by weight polyacrylic acid crosslinked fibers) and southern pine fibers (15 percent by weight refined fibers, 500 CSF); unsoftened Layer B includes a refined blend of crosslinked fibers (80 percent by weight polyacrylic acid crosslinked fibers) and southern pine fibers (20 percent by weight refined fibers, 500 CSF); unsoftened Layer C includes a refined blend of crosslinked fibers (85 percent by weight DMeDHEU crosslinked fibers, commercially available from Weyerhaeuser Co. under the designation NHB 416) and southern pine fibers (15 percent by weight refined fibers, 500 CSF); and softened (embossed) Layer D includes a refined blend of crosslinked fibers (85 percent by weight DMeDHEU crosslinked fibers) and southern pine fibers (15 percent by weight refined fibers, 500 CSF). As used herein, the term "unsoftened" refers to a layer that has not been subjected to mechanical treatment, such as, for example, calendering, tenderizing, or embossing. The data presented in Table 1 was acquired using a TRI Autoporosimeter Device.

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Table 1. Performance Characteristics of Representative Distribution Layers.

Layer	Ring Crush (g)	MD,CD Gurley Stiffness SGU/mm	Peak Geometric Mean Tensile (g/cm)	MDP:MAP* Ratio	MDP*	MAP*	MUP*	Surface Tension (dynes/cm)
A	3405	1137, 562	858.0	1.81:1	24.2	13.4	10.0	65.5
B	1500	650, 266	763.5	1.72:1	22.1	12.9	9.5	69.6
C	1500	623, 390	725.5	1.91:1	29.0	15.2	9.2	66.8
D	900	351, 163	546.5	1.98:1	28.5	14.4	8.1	66.8

Table 2. Performance Characteristics of Representative Distribution Layers.

Layer	Ave. O.D. Basis Weight (gsm)	Ave. A.D. Basis Weight (gsm)	Wicking Time to 15 cm (sec)	Wicking Height at 15 min (cm)	Wicking Capacity at 15 cm after 15 min (g/g)	MD,CD Tensile (g/cm)	MD,CD Elongation (%)
A	88	0.114	174	21.8	8.6	1020, 696	2.6, 5.6
B	52	0.117	291	19.8	7.3	952, 575	2.4, 4.1
C	53	0.126	277	19.2	7.7	899, 552	2.7, 3.8
D	53	0.165	326	18.6	7.5	651, 442	2.8, 5.1

In addition to cellulosic fibers, the distribution layer can include a wet strength agent. Suitable wet strength agents are described below. The wet strength agent is present in the layer in an amount from about 5 to about 20 pounds/ton fiber. In one embodiment, the wet strength agent is a polyamide-epichlorohydrin resin present in the layer in about 10 pounds/ton fiber.

As noted above, the distribution layer of the invention includes crosslinked cellulosic fibers. Any one of a number of crosslinking agents and crosslinking catalysts,

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if necessary, can be used to provide the crosslinked fibers to be included in the layer. The following is a representative list of useful crosslinking agents and catalysts. Each of the patents noted below is expressly incorporated herein by reference in its entirety.

Suitable urea-based crosslinking agents include substituted ureas such as methylolated ureas, methylolated cyclic ureas, methylolated lower alkyl cyclic ureas, methylolated dihydroxy cyclic ureas, dihydroxy cyclic ureas, and lower alkyl substituted cyclic ureas. Specific urea-based crosslinking agents include dimethyldihydroxy urea (DMDHU, 1,3-dimethyl-4,5-dihydroxy-2-imidazolidinone), dimethyloldihydroxyethylene urea (DMDHEU, 1,3-dihydroxymethyl-4,5-dihydroxy-2-imidazolidinone), dimethylol urea (DMU, bis[N-hydroxymethyl]urea), dihydroxyethylene urea (DHEU, 4,5-dihydroxy-2-imidazolidinone), dimethylolethylene urea (DMEU, 1,3-dihydroxymethyl-2-imidazolidinone), and dimethyldihydroxyethylene urea (DMeDHEU or DDI, 4,5-dihydroxy-1,3-dimethyl-2-imidazolidinone).

Suitable crosslinking agents include dialdehydes such as C₂-C₈ dialdehydes (e.g., glyoxal), C₂-C₈ dialdehyde acid analogs having at least one aldehyde group, and oligomers of these aldehyde and dialdehyde acid analogs, as described in U.S. Patents Nos. 4,822,453; 4,888,093; 4,889,595; 4,889,596; 4,889,597; and 4,898,642. Other suitable dialdehyde crosslinking agents include those described in U.S. Patents Nos. 4,853,086; 4,900,324; and 5,843,061.

Other suitable crosslinking agents include aldehyde and urea-based formaldehyde addition products. See, for example, U.S. Patents Nos. 3,224,926; 3,241,533; 3,932,209; 4,035,147; 3,756,913; 4,689,118; 4,822,453; 3,440,135; 4,935,022; 3,819,470; and 3,658,613.

Suitable crosslinking agents include glyoxal adducts of ureas, for example, U.S. Patent No. 4,968,774, and glyoxal/cyclic urea adducts as described in U.S. Patents Nos. 4,285,690; 4,332,586; 4,396,391; 4,455,416; and 4,505,712.

Other suitable crosslinking agents include carboxylic acid crosslinking agents such as polycarboxylic acids. Polycarboxylic acid crosslinking agents (e.g., citric acid, propane tricarboxylic acid, and butane tetracarboxylic acid) and catalysts are described in U.S. Patents Nos. 3,526,048; 4,820,307; 4,936,865; 4,975,209; and 5,221,285. The use of C₂-C₉ polycarboxylic acids that contain at least three carboxyl groups (e.g., citric acid and

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oxydisuccinic acid) as crosslinking agents is described in U.S. Patents Nos. 5,137,537; 5,183,707; 5,190,563; 5,562,740, and 5,873,979.

Polymeric polycarboxylic acids are also suitable crosslinking agents. Suitable polymeric polycarboxylic acid crosslinking agents are described in U.S. Patents Nos. 4,391,878; 4,420,368; 4,431,481; 5,049,235; 5,160,789; 5,442,899; 5,698,074; 5,496,476; 5,496,477; 5,728,771; 5,705,475; and 5,981,739. Polyacrylic acid and related copolymers as crosslinking agents are described U.S. Patents Nos. 5,549,791 and 5,998,511. Polymaleic acid crosslinking agents are described in U.S. Patent No. 5,998,511.

Specific suitable polycarboxylic acid crosslinking agents include citric acid, tartaric acid, malic acid, succinic acid, glutaric acid, citraconic acid, itaconic acid, tartrate monosuccinic acid, maleic acid, polyacrylic acid, polymethacrylic acid, polymaleic acid, polymethylvinylether-co-maleate copolymer, polymethylvinylether-co-itaconate copolymer, copolymers of acrylic acid, and copolymers of maleic acid.

Other suitable crosslinking agents are described in U.S. Patents Nos. 5,225,047; 5,366,591; 5,556,976; and 5,536,369.

Suitable catalysts can include acidic salts, such as ammonium chloride, ammonium sulfate, aluminum chloride, magnesium chloride, magnesium nitrate, and alkali metal salts of phosphorous-containing acids. In one embodiment, the crosslinking catalyst is sodium hypophosphite.

Mixtures or blends of crosslinking agents and catalysts can also be used.

The crosslinking agent is applied to the cellulosic fibers in an amount sufficient to effect intrafiber crosslinking. The amount applied to the cellulosic fibers can be from about 1 to about 10 percent by weight based on the total weight of fibers. In one embodiment, crosslinking agent in an amount from about 4 to about 6 percent by weight based on the total weight of fibers.

In addition to crosslinked fibers, the distribution layer of the invention also includes noncrosslinked cellulosic fibers. Suitable cellulosic fibers include those known to those skilled in the art and include any fiber or fibrous mixture from which a fibrous web or sheet can be formed.

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Although available from other sources, cellulosic fibers are derived primarily from wood pulp. Suitable wood pulp fibers for use with the invention can be obtained from well-known chemical processes such as the kraft and sulfite processes, with or without subsequent bleaching. Pulp fibers can also be processed by thermomechanical, chemithermomechanical methods, or combinations thereof. The preferred pulp fiber is produced by chemical methods. Groundwood fibers, recycled or secondary wood pulp fibers, and bleached and unbleached wood pulp fibers can be used. Softwoods and hardwoods can be used. Details of the selection of wood pulp fibers are well known to those skilled in the art. These fibers are commercially available from a number of companies, including Weyerhaeuser Company, the assignee of the present invention. For example, suitable cellulose fibers produced from southern pine that are usable with the present invention are available from Weyerhaeuser Company under the designations CF416, NF405, PL416, FR516, and NB416.

The wood pulp fibers useful in the present invention can also be pretreated prior to use. This pretreatment may include physical treatment, such as subjecting the fibers to steam, or chemical treatment. Other pretreatments include incorporation of antimicrobials, pigments, dyes and densification or softening agents. Fibers pretreated with other chemicals, such as thermoplastic and thermosetting resins also may be used. Combinations of pretreatments also may be employed. Treatments can also be applied after formation of the fibrous product in post-treatment processes, examples of which include the application of surfactants or other liquids, which modify the surface chemistry of the fibers, and the incorporation of antimicrobials, pigments, dyes, and densification or softening agents.

The distribution layer optionally includes a wet strength agent. Suitable wet strength agents include cationic modified starch having nitrogen-containing groups (e.g., amino groups) such as those available from National Starch and Chemical Corp., Bridgewater, NJ; latex; wet strength resins, such as polyamide-epichlorohydrin resin (e.g., KYMENE 557LX, Hercules, Inc., Wilmington, DE), and polyacrylamide resin (see, e.g., U.S. Patent No. 3,556,932 and also the commercially available polyacrylamide marketed by American Cyanamid Co., Stamford, CT, under the trade name PAREZ 631 NC); urea formaldehyde and melamine formaldehyde resins; and polyethylenimine

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resins. A general discussion on wet strength resins utilized in the paper field, and generally applicable in the present invention, can be found in TAPPI monograph series No. 29, "Wet Strength in Paper and Paperboard", Technical Association of the Pulp and Paper Industry (New York, 1965).

In another aspect of the invention, methods for forming the distribution layer are provided. Representative distribution layers can be formed using conventional papermaking machines including, for example, Rotoformer, Fourdrinier, inclined wire Delta former, and twin-wire machines.

The layer can be formed by devices and processes that include a twin-wire configuration (i.e., twin-forming wires). Representative forming methods applicable for forming the distribution layer of the invention are described in PCT/US99/05997 (Method for Forming a Fluted Composite) and PCT/US99/27625 (Reticulated Absorbent Composite), each incorporated herein by reference in its entirety. A representative twin-wire machine for forming the layer is shown in FIGURE 1. Referring to FIGURE 1, machine 200 includes twin-forming wires 202 and 204 onto which the layer's components are deposited. Basically, fibrous slurry 124 is introduced into headbox 212 and deposited onto forming wires 202 and 204 at the headbox exit. Vacuum elements 206 and 208 dewater the fibrous slurries deposited on wires 202 and 204, respectively, to provide partially dewatered webs that exit the twin-wire portion of the machine as partially dewatered web 126. Web 126 continues to travel along wire 202 and continues to be dewatered by additional vacuum elements 210 to provide wet composite 120 which is then dried by drying means 216 to provide layer 10.

In one embodiment, the composite is formed by a wetlaid process using the components described above. The wetlaid method can be practiced on an inclined wire Delta former. In another embodiment, the composite is formed by a foam-forming method using the components described above. Wetlaid and foam-forming processes can be practiced on a twin-wire former.

A representative method for forming a distribution layer of the invention includes the following steps:

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- (a) forming a fibrous slurry comprising fibers in an aqueous dispersion medium; for a foam method, the slurry is a foam that includes, in addition to fibers, a surfactant;
- (b) moving a first foraminous element (e.g., a forming wire) in a first path;
- (c) moving a second foraminous element in a second path;
- (d) passing a first portion of the slurry into contact with the first foraminous element moving in a first path;
- (e) passing a second portion of the slurry into contact with the second foraminous element moving in the second path; and
- (f) forming a fibrous web from the slurry by withdrawing liquid from the slurry through the first and second foraminous elements.

As noted above, the foam-forming method is suitably carried out on a twin-wire former, preferably a vertical former, and more preferably, a vertical downflow twin-wire former. In the vertical former, the paths for the foraminous elements are substantially vertical.

A representative vertical downflow twin-wire former useful in practicing a method of the invention is illustrated in FIGURE 2. Referring to FIGURE 2, the former includes a vertical headbox assembly having a former with a closed first end (top), closed first and second sides and an interior volume. A second end (bottom) of the former is defined by moving first and second foraminous elements, 202 and 204, and forming nip 213. The interior volume defined by the former's closed first end, closed first and second sides, and first and second foraminous elements includes an interior structure 230 extending from the former first end and toward the second end. The interior structure defines a first volume 232 on one side thereof and a second volume 234 on the other side thereof. The former further includes supply 242 and means 243 for introducing a first fiber/foam slurry into the first volume, supply 244 and means 245 for introducing a second fiber/foam slurry into the second volume, and supply 246 and means 247 for introducing a third material (e.g., the first or second fiber/foam slurry) into the interior structure. Means for withdrawing liquid/foam (e.g., suction boxes 206 and 208) from the first and second slurries through the foraminous elements to form a web are also included in the headbox assembly.

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In the method, the twin-wire former includes a means for introducing at least a third material (e.g., the first or second fiber/foam slurry) through the interior structure. The first and second fiber/foam slurries can include the same components (e.g., crosslinked cellulosic fibers, southern pine fibers, eucalyptus fibers) and have the same composition.

Depending upon the nature of the composite to be formed, the first and second fiber/foam slurries may be the same as or different from each other, and the same as or different from a third material.

The means for withdrawing liquid/foam from the first and second slurries through the foraminous elements to form a web on the foraminous elements are also included in the headbox assembly. The means for withdrawing liquid/foam can include any conventional means for that purpose, such as suction rollers, pressing rollers, or other conventional structures. In a preferred embodiment, first and second suction box assemblies are provided and mounted on the opposite sides of the interior structure from the foraminous elements (see boxes 206 and 208 in FIGURES 1 and 2).

The distribution layer of the invention advantageously exhibits strength (e.g., structural integrity) and softness. In addition to having flexibility and softness suitable for incorporation into personal care absorbent products, the composites of the invention exhibit advantageous structural integrity. Structural integrity can be indicated by tensile strength. Suitable layers have a tensile strength greater than about 10 N/50 mm.

Suitable layers have a machine direction (MD) tear strength greater than about 205 mN, and a cross-machine direction (CD) tear strength greater than about 260 mN. The tear strength of representative distribution layers of the invention was determined by ASTM Method No. P-326-5. In the method, the machine direction (MD) and cross-machine direction (CD) tear strengths of 10 specimens of representative layers (1-3 in Table 1 below) were measured. Layer 1 included 85 percent by weight crosslinked fibers, 8 percent by weight eucalyptus fibers, and 7 percent by weight southern pine fibers. Layer 2 included 85 percent by weight crosslinked fibers, 8 percent by weight eucalyptus fibers, and 7 percent by weight refined southern pine fibers. Layer 3 included 85 percent by weight crosslinked fibers, 8 percent by weight hardwood fibers (Westvaco),

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and 7 percent by weight refined southern pine fibers. The average, maximum, minimum tear strengths as well as their ranges (mN) are summarized in Table 3.

Table 3. Representative Distribution Layer Tear Strength.

Layer	Average	Maximum	Minimum	Range
1 (MD)	242.2	284.4	215.7	68.6
1 (CD)	322.6	362.8	304.0	58.8
2 (MD)	419.7	431.5	402.1	29.4
2 (CD)	531.5	559.0	490.3	68.6
3 (MD)	388.3	431.5	362.8	68.6
3 (CD)	514.8	588.4	460.9	127.5

Extracts of suitable layers have a surface tension greater than about 50 dynes/cm. The method for determining the surface tension of a pulp extract is described below.

Suitable layers have a softness, as measured by ring crush, less than about 1200 g.

The distribution layer of the invention exhibits advantageous fluidic properties. The properties can be indicated by various measures including liquid acquisition rate, rewet, wicking, mid-point desorption pressure, mid-point acquisition pressure, and mid-point uptake.

The layer has a mid-point desorption pressure (MDP) greater than about 20 cm. In one embodiment, the layer has a MDP greater than about 30 cm. In another embodiment, the layer has a MDP greater than about 40 cm.

The layer has a mid-point acquisition pressure (MAP) less than about 25 cm. In one embodiment, the layer has a MAP less than about 20 cm.

The layer has a mid-point uptake (MU) greater than about 5 g/g.

A description of the method for determining MDP, MAP, and MU is provided in Liquid Porosimetry: New Methodology and Applications, B. Miller and I. Tomkin, Journal of Colloid Interface Science, 162:163-170, 1994, incorporated herein by reference in its entirety.

Liquid transfer rate was determined by soaking a strip of representative distribution layer (10 cm width) with synthetic urine. The soaked layer was allowed to

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drain for 3 minutes on the test device. The test device on which the layer was placed included a horizontal surface adjacent a 60 degree sloped surface (i.e., a ramp). The distribution layer extended across the horizontal and sloped portions of the device with one end terminating in a reservoir containing a known amount of synthetic urine. The horizontal surface was 11 cm above the lower edge of the sloped surface. A receiving layer (e.g., storage layer, 10 cm x 10 cm) was placed on top of the distribution layer on the horizontal surface. A weight (704 g, 10 cm x 10 cm delivering 0.10 psi) was placed on top of the receiving layer. The receiving layer was allowed to absorb for 20 minutes against the 15 cm head. The amount of liquid transferred from the reservoir was measured and the transfer rate calculated.

The layer of the invention provides a liquid transfer rate greater than zero at a wicking height of 11 cm when incorporated as the distribution layer into a commercial infant diaper (PAMPERS).

Other physical and performance characteristics of representative distribution layers of the invention (Layers 4-8) are summarized in Table 4 below. Layer 4 included 85 percent by weight crosslinked fibers, 8 percent by weight eucalyptus fibers, and 7 percent by weight southern pine fibers. Layers 5-8 were derived from Layer 4 by softening under varying conditions (4, 12, 16, and 17, respectively) as described below in Table 4. Layer 5 was softened by applying a pressure of 35 bar with a cold calender roll; Layer 6 was softened by applying a pressure of 35 bar with a cold calender roll and 2 bar in the layer's machine direction; Layer 7 was softened by applying a pressure of 35 bar with a cold calender roll and embossing the top and bottom surfaces of the layer (2 passes) at a pressure of 8 bar; and Layer 8 was softened by applying a pressure of 8 bar to the layer's machine and cross-machine directions.

Table 4. Representative Distribution Layer Physical and Performance Characteristics.

Distribution Layer	4	5	6	7	8
Test					
Capsorption					
MDP (cm)	32.2	44.2	43.5	42	35.3
MAP (cm)	17.5	23.6	22.3	22.3	18.8
MU (g/g)	7	5.4	5.8	5.3	6.8
Softness (ring crush, g)	2700	1070	320	330	250
Tensile (N/50mm)	29.2	20.8	12.2	8.9	2.3
Surface tension	48	53	52	52	53
Brightness	72.2	73.7	73.7	74.1	73.1
Basis weight (g/m ²)	152	152	153	153	137
Caliper (mm)	1.29	0.54	0.77	0.72	1.30
Density (g/cm ³)	0.118	0.283	0.200	0.212	0.105
Wicking time to 15 cm (sec)	273	238	240	248	710
Wick capacity @ 15 cm (g/g)	6.6	6	6.2	6.4	7.1
Wicked Ht. @ 15 min (cm)	19.2	21	21.2	20.2	15.2
Softness					
Cantilever Stiffness, MD (mm)	107	59	53	41	39
Cantilever Stiffness, CD (mm)	83	51	29	27	37
Strength					
Dry Tensile, MD (N/50mm)	29.2	20.8	12.2	8.9	2.3

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Dry Elong. (mm)	4.3	4.9	5.5	6.5	9.7
Dry Elong. (%)	2.1	2.5	2.7	3.2	4.8
Wet Tensile, MD (N/50mm)	8.9	5.1	3.4	2.1	0.7
Wet Elong. (mm)	11.3	12.4	13.3	13.1	10.4
Wet Elong. (%)	5.7	6.2	6.7	6.6	5.2
Wet Strength (W/D%)	31	25	28	24	28
Capacity (g/g pad)	3.8	3.6	3.6	3.8	3.7

Wick time and tensile versus cantilever stiffness for Layers 4-8 is illustrated graphically in FIGURE 3.

Fluid transfer to core versus time for Layers 4, 5, and 8 is illustrated graphically in FIGURE 4.

The distribution layer formed in accordance with the present invention can be incorporated into an absorbent article such as a diaper. The composite can be used alone or combined with one or more other layers, such as acquisition and/or storage layers, to provide useful absorbent constructs.

Representative absorbent constructs that incorporate the distribution layer are illustrated in FIGURES 12A-C. Referring to FIGURE 12A, representative distribution layer 10 can be combined with a storage layer 20 to provide construct 100. Referring to FIGURE 12B, acquisition layer 30 can be combined with distribution layer 10 and storage layer 20 to provide construct 110 having distribution layer 10 intermediate acquisition layer 30 and storage layer 20. Referring to FIGURE 12C, acquisition layer 30 can be combined with distribution layer 10 and storage layer 20 to provide construct 120 having storage layer 20 intermediate acquisition layer 30 and distribution layer 10.

As noted above, the distribution layer can be incorporated into personal care absorbent products, such as infant diapers, training pants, and incontinence products. Representative absorbent articles that incorporate the distribution layer are illustrated in FIGURES 13A-D. In general, the absorbent articles include an absorbent construct intermediate a liquid pervious face sheet and a liquid impervious back sheet. Typically,

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in such absorbent articles, the face sheet is joined to the back sheet. Referring to FIGURE 13A, article 200 includes face sheet 40, distribution layer 10, storage layer 20, and back sheet 50. In this article, distribution layer 10 is adjacent face sheet 40. Referring to FIGURE 13B, article 205 includes face sheet 40, storage layer 20, distribution layer 10, and back sheet 50 with distribution layer 10 adjacent back sheet 50. Referring to FIGURE 13C, article 210 includes face sheet 40, acquisition layer 30, distribution layer 10, storage layer 20, and back sheet 50. In this article, distribution layer 10 is intermediate acquisition layer 30 and storage layer 20. Referring to FIGURE 13D, article 220 includes face sheet 40, acquisition layer 30, storage layer 20, distribution layer 10, and back sheet 50. In this article, distribution layer 10 is adjacent back sheet 50.

It will be appreciated that absorbent constructs and articles that include the distribution layer of the invention can have a variety of designs and are within the scope of this invention.

The distribution layer was tested in training pants.

In the following tests the training pants contain SAP. As used herein, a SAP or "superabsorbent particles" or "superabsorbent material" refers to a polymeric material that is capable of absorbing large quantities of fluid by swelling and forming a hydrated gel (i.e., a hydrogel). In addition to absorbing large quantities of fluids, superabsorbent materials can also retain significant amounts of bodily fluids under moderate pressure.

Superabsorbent materials generally fall into three classes: starch graft copolymers, crosslinked carboxymethylcellulose derivatives, and modified hydrophilic polyacrylates. Examples of such absorbent polymers include hydrolyzed starch-acrylonitrile graft copolymers, neutralized starch-acrylic acid graft copolymers, saponified acrylic acid ester-vinyl acetate copolymers, hydrolyzed acrylonitrile copolymers or acrylamide copolymers, modified crosslinked polyvinyl alcohol, neutralized self-crosslinking polyacrylic acids, crosslinked polyacrylate salts, carboxylated cellulose, and neutralized crosslinked isobutylene-maleic anhydride copolymers.

Superabsorbent materials are available commercially, for example, polyacrylates from Clariant of Portsmouth, Virginia. These superabsorbent polymers come in a variety of sizes, morphologies, and absorbent properties (available from Clariant under trade

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designations such as IM 3500 and IM 3900). Other superabsorbent materials are marketed under the trademarks SANWET (supplied by Sanyo Kasei Kogyo Kabushiki Kaisha), and SXM77 (supplied by Stockhausen of Greensboro, North Carolina). Other superabsorbent materials are described in U.S. Patent No. 4,160,059; U.S. Patent No. 4,676,784; U.S. Patent No. 4,673,402; U.S. Patent No. 5,002,814; U.S. Patent No. 5,057,166; U.S. Patent No. 4,102,340; and U.S. Patent No. 4,818,598, all expressly incorporated herein by reference. Products such as diapers that incorporate superabsorbent materials are described in U.S. Patent No. 3,699,103 and U.S. Patent No. 3,670,731.

The first control training pant was a large "Members Mark" Kids Pants (Paragon Training Pant) which has a storage core containing approximately 46% SAP. The storage core has a capacity of approximately 380 mls (milliliters) of urine. The core contains 13 grams of SAP mixed with 15 grams of airlaid fluff pulp.

This control was compared to two test training pants. Each of the test training pants used the same control training pant. In each of the test training pants a distribution layer was placed under the storage core.

In the first test training pant, also called Paragon Training Pant with UDL 1049-5, the UDL distribution layer had a weight of 180 gsm (grams per square meter) and a capacity of 48 mls of urine. It contained 8 grams of fiber.

In the second test pant, also called Paragon Training Pant with UDL 1081-8, the UDL distribution layer had a weight of 90 gsm and a capacity of 24 mls of urine. It contained 4 grams of fiber.

The second control training pant was a large "Members Mark" Kids Pants (Paragon Training Pant with 70% core) which has a storage core containing approximately 70% SAP. The storage core has a capacity of approximately 320 mls of urine. The core contains 13 grams of SAP mixed with 5.5 grams of airlaid treated fluff pulp. The pulp was mixed with a mixture of equal molecular amounts of propylene glycol, lactic acid and sodium lactate. The amount of the mixture on the pulp was 7-9% of the weight of the pulp.

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This control was also compared to two test training pants. Each of the test training pants used the same control training pant. In each of the test training pants a distribution layer was placed under the storage core.

In the first test training pant, also called Paragon Training Pant with 70% core and UDL 1049-5, the UDL distribution layer had a weight of 180 gsm and a capacity of 48 mls of urine. It contained 8 grams of fiber.

In the second test pant, also called Paragon Training Pant with 70% core and UDL 1081-8, the UDL distribution layer had a weight of 90 gsm and a capacity of 24 mls of urine. It contained 4 grams of fiber.

Saddle Wicking Test

Saddle wicking, including acquisition rate, distribution, and wicking height, was determined by the method described below.

Procedure:

- 1) Draw and label the 6 even cells using a template and a permanent marker.
- 2) Place an "X" at the midpoint of the line between the 3rd and 4th cells.
- 3) Position diaper in Saddle Device so that the "X" is squarely at the bottom of the apparatus and then position a 250 ml separatory funnel approximately 1 cm directly above the "X."
- 4) Measure out 75ml of synthetic urine (Blood Bank 0.9% saline) and pour into funnel.
- 5) Open the funnel and start the timer. Measure the time at which all of the fluid has left the funnel to the point where the fluid is absorbed into the sample. Record as acquisition time.
- 6) Repeat steps 7 and 8 every 20 minutes, until the training pant leaks (Free fluid in training pant 20 minutes after the insult or fluid addition)
- 7) When the diaper has leaked extract the free fluid out of the training pant using a syringe.
- 8) Measure and record the amount of free fluid extracted in step 7.
- 9) Pull out training pant and cut sample into designated cells.
- 10) Weigh each cell and record the wet weight.
- 11) Place each cell into oven to dry.

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- 12) Weigh and record dry weights of each cell.
- 13) Calculate the amount of fluid in each cell (wet weight – dry weight).
- 14) Calculate the capacity utilized before leakage ((number of insults x 75ml) – free fluid extracted).

The results of the saddle wicking tests are shown in FIGURES 5 through 11. FIGURE 5 shows the time in seconds to acquire fluid during the 4th insult for the control and test training pants, and demonstrates the effectiveness of the UDL in transferring fluid so the core can acquire fluid more rapidly. FIGURE 6 shows the total fluid absorbed in milliliters before leakage occurred. FIGURES 7 and 8 show the distribution of fluid in grams in each of the zones of the training pant.

Market Pulp Flat Acquisition Test

Acquisition time and rewet were obtained for the control and test training pants.

The acquisition time and rewet are determined in accordance with the multiple-dose rewet test described below.

Briefly, the multiple-dose rewet test measures the amount of synthetic urine released from an absorbent structure after each of three liquid applications, and the time required for each of the three liquid doses to wick into the product.

The aqueous solution used in the tests was a synthetic urine made up of one part synthetic urine concentrate and nine parts deionized water..

The training pant was clamped onto a clampboard, fully extended, with the nonwoven side up. The training pant was prepared for the test by determining the center of the structure's core, measuring 2.5 cm. to the front for liquid application location, and marking the location with an "X". A dosing ring (5/32 inch stainless steel, 2 inch ID x 3 inch height) was placed onto the "X" marked on the samples. A liquid application funnel (minimum 100 mL capacity, 5-7 mL/s flow rate) was placed 2-3 cm. above the dosing ring at the "X". Once the sample was prepared, the test was conducted as follows.

The funnel was filled with a dose (75 mL) of synthetic urine. A first dose of synthetic urine was applied within the dosing ring. Using a stopwatch, the liquid acquisition time was recorded in seconds from the time the funnel valve was opened until the liquid wicked into the product from the bottom of the dosing ring. The acquisition rate was determined by dividing the amount of synthetic urine (75 ml) by the acquisition

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time to obtain the acquisition rate in grams per second. A milliliter of synthetic urine is equal to 1 gram.

After a twenty-minute wait period, rewet was determined. During the twenty-minute wait period after the first dose was applied, a stack of filter papers (19-22 g, Whatman #3, 11.0 cm or equivalent, that had been exposed to room humidity for minimum of 2 hours before testing) was weighed. The stack of preweighed filter papers was placed on the center of the wetted area. A cylindrical weight (8.9 cm diameter, 9.8 lb.) was placed on top of these filter papers. After two minutes the weight was removed, the filter papers were weighed and the weight change recorded.

The procedure was repeated two more times. Another 75ml dose of synthetic urine was added to the diaper, and the acquisition time and rate was determined, filter papers were placed on the sample for two minutes, and the weight change determined. For the second dose, the weight of the dry filter papers was 29-32 g, and for the third dose, the weight of the filter papers was 39-42 g. The dry papers from the prior dosage were supplemented with additional dry filter papers.

FIGURE 9 shows the acquisition rate of the 3rd insult in grams per second. FIGURE 10 shows the acquisition rate for three successive insults in grams per second.

Rewet is reported as the amount of liquid (grams) absorbed back into the filter papers after each liquid dose (i.e., difference between the weight of wet filter papers and the weight of dry filter papers). FIGURE 11 shows the rewet after the 4th insult.

Pulp Extract Surface Tension Method

The following method is used to determine the surface tension of pulp extracts. In the method, pulp fibers are mixed with water to extract residue and contaminants. The surface tension of the filtrate is measured to demonstrate the surface activity of the extractives and their relative concentration on the pulp fibers. The procedure is described below.

- A. Wearing gloves to prevent contamination, remove a 2.0 gram subsample of pulp from a pulp sheet and place in a clean, dry 125-mL Nalgene bottle.
- B. Add 100 mL of deionized water and cap the bottle tightly.
- C. Place the bottle on a wrist action shaker and shake on high intensity for 1 hour.

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D. Remove the bottle from the shaker and allow to stand for 10 minutes. This helps to separate the fibers from the water before filtering.

E. Assemble a filtration apparatus using a clean, dry 125-mL Nalgene bottle inside a filter box with an 11.0 cm Buchner funnel placed on top. Place an 11.0 cm Whatman grade #4 filter paper in the Buchner funnel. An equivalent filter can be used if it has the following specifications: fast qualitative type, 12 sec./100 mL filtration speed, 0.06% ash content, and 20-25 μ particle size retention.

F. Attach the filter assembly to a standard (25 in. of Hg) vacuum system.

G. Turn on the vacuum system, uncap the sample bottle, and pour the contents onto the filter in the Buchner funnel. All the filtrate should be removed from the pulp fibers in 15-30 seconds.

H. Turn off the vacuum system and remove the collection bottle from the filter box. Swirl the filtrate in the bottle to ensure thorough mixing.

I. Calibrate the Rosano plate surface tensiometer by using deionized water at room temperature (25°C) and the platinum plate labeled for surfactants. Condition the plate by dipping in acetone and passing through the flame of a bunsen burner until it glows red. Allow the plate to cool for 10 seconds before using. Conditioning must take place between every sample and every sample replicate.

J. Pour 20 mL of deionized water into a clean, dry 25-mL glass petri dish. Measure the surface tension and perform a duplicate. The surface tension of deionized water at 25°C is 71.8 dynes/cm. The surface tensiometer is calibrated if each duplicate reading is 71.8 ± 1 dynes/cm.

K. Using the filtrate in the sample bottle, pour 20 mL aliquotes into three clean, dry 25-mL petri dishes.

L. Measure the surface tension of each replicate and report the average. Each replicate should be within ± 2 dynes/cm. A replicate should be repeated if bubbles are on the surface or within the solution: bubbles adversely affect the reading.

The distribution layer of the invention is effective in distributing acquired liquid to an adjacent liquid storage layer. The physical characteristics of representative distribution layers are summarized in Tables 5 and 8. The characteristics of liquid distribution from a representative distribution layer to an adjacent airlaid storage layer are

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summarized in Tables 6, 7, and 9. The performance of representative distribution layers of the invention is compared to other distribution materials (e.g., tissue, towel) in Tables 6 and 7. In each instance, a distribution material was placed in liquid communication with an airlaid storage layer (i.e., basis weight about 360 gsm; 0.13 g/cm³ density; 70 percent by weight superabsorbent material, SXM-77 from Stockhausen, and 30 percent by weight pulp fibers commercially available from Weyerhaeuser under the designation RP-S3, pulp fibers treated with a combination of about 43 percent lactic acid, about 40 percent sorbitol, and about 17 percent propylene glycol in water) and contacted with a liquid according to the Pressurized Vertical Wicking (PVW) Testing Procedure described below.

In Tables 6 and 7, test results are presented for (1) the distribution material alone, (2) the storage core alone, and (3) the combination of the distribution material and storage layer. The tested structures included the following distribution materials: commercial grade tissue, 3 layers at 22 gsm each (Sample A); CROWN dispenser pack white C-fold towels from Fort James Corp. at 38 gsm per ply (Sample B); and BOUNTY towels, consumer product from Procter & Gamble Corp. at 52 gsm (Sample C). The storage layer as described above is identified as Sample D. Absorbent constructs combining the distribution material and storage layer were also tested: Sample B and storage layer (Sample E); two plies of Sample B and storage layer (Sample F); three plies of Sample B and storage layer (Sample G); storage layer intermediate two plies of Sample B (Sample H); Sample A and storage layer (Sample I); Sample C and storage layer (Sample J); and storage layer and a representative distribution layer of the invention (basis weight 89 gsm, 85 percent by weight polyacrylic acid crosslinked fibers and 15 percent by weight refined southern pine) (Sample K). Sample L (Table 7) is a representative distribution layer of the invention (refined blend of 85 percent by weight polyacrylic acid crosslinked fibers and 15 percent by weight refined southern pine). The physical characteristics of the tested structures, Samples A-K, are summarized in Table 5.

Table 5. Absorbent Structure Physical Characteristics.

Sample	Sample Basis Weight (gsm)	Distribution Basis Layer Weight (gsm)	Sample Weight (g)	Distribution Weight Layer Weight (g)
A	3x22	66	1.41	1.41
B	38	38	0.87	0.87
C	52	52	1.08	1.09
D	360	0	7.14	0
E	38+360	38	8.70	0.85
F	38+38+360	76	9.34	1.68
G	38+38+38+360	114	10.40	2.52
H	38+360+38	76	10.07	1.71
I	3x22 + 360	66	9.13	1.40
J	52+360	52	8.54	1.08
K	89+360	89	10.19	1.88

Table 6. Absorbent Structure Absorption Properties.

Sample	Maximum Instant. Absorpt. Rate: g/min	Maximum Smoothed Absorpt. Rate: g/min	30 min. Absorpt. Rate g/min	g/g/min	Smoothed Absorpt. Rate @ 30 min.: g/min	Mass Absorbed in 30 min. g	g/g	Mass Abs'd over Core only g	Mass over Core norm'd by DL wt g/g
	30.6	21.7			0.03	4.3	3.1		
	4.1	4.7			0.17	5.8	6.7		
	3.2	3.0			0.05	1.7	1.6		
	47.0	6.5			0.38	45.3	6.3	0.0	0
	42.0	4.8			0.49	54.7	6.3	9.4	11.11
	40.4	4.3			0.55	55.9	6.0	10.7	6.36
	49.6	4.8			0.57	66.1	6.4	20.9	8.28
	53.8	5.3			0.53	57.0	5.7	11.8	6.90
	68.0	7.5			0.48	61.6	6.7	16.3	11.70
	110.6	13.0			0.50	72.1	8.4	26.8	24.85
	52.0	5.1			0.89	116.1	11.4	70.8	37.75

Table 7. Absorbent Structure Absorption Properties.

Sample	Fluid Absorbed in 30. min.		30 min. Absorption Rate		Instantaneous Rate @ 30 min.		Fluid Absorbed over Core only	Fluid over Core normalized by Distrib. Matl. Wt.	Fluid Retained in Distrib. Matl.	30 min. Transfer Rate to Core	30 min. Flux thru Distrib. Material
	g	g/g	g/min	g/g/min	g/min	g/g/min	g	g/g	g	g/min	g/min/cm ²
	4.3	3.1	0.1	0.10	.03	.02	-	-	.40	-	-
	5.8	6.7	0.2	0.22	0.17	0.20	-	-	1.47	-	-
	1.7	1.6	0.1	0.05	0.05	0.05	-	-	3.99	-	-
	14.2*	7.7*	0.7*	0.36*	0.0*	0.0*	-	-	10.88	-	-
	45.3	6.3	1.5	0.21	0.38	0.05	0.0	0.0	-	-	-
	54.7	6.3	2.0	0.24	0.49	0.06	9.4	11.1	1.23	0.27	0.99
	55.9	6.0	1.9	0.20	0.55	0.06	10.7	6.4	2.34	0.28	0.61
	66.1	6.4	2.2	0.21	0.57	0.05	20.9	8.3	4.17	0.56	0.81
	57.0	5.7	1.9	0.19	0.53	0.05	11.8	6.9	2.01	0.33	0.67
	61.6	6.7	2.1	0.22	0.48	0.05	16.3	11.7	1.99	0.48	2.13
	72.1	8.4	2.4	0.28	0.50	0.06	26.8	24.8	3.35	0.78	1.83
	116.1	11.4	3.9	0.38	0.89	0.09	70.8	37.7	8.89	2.06	3.15

* Sample wicked to full height of 21 cm in 21.4 min.k, less than the 30 minute test.

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Referring to Table 6, Sample K, which included a representative distribution layer of the invention, significantly outperformed other distribution materials. For example, the liquid absorption rate for the sample at 30 minutes was 3.9 g/min (normalized for sample weight, 0.38 g/g/min), while the closest other sample, Sample J, had a rate of 2.4 g/min (0.28 g/g/min). The rate was more than 50 percent greater for the layer of the invention. Similarly, the mass of liquid absorbed in 30 minutes for Sample K was 116.1 g compared to 72.1 g for Sample J, and mass of liquid absorbed over the core for Sample K was 70.8 g (normalized for distribution layer weight, 37.75 g) compared to 26.8 g (normalized for distribution layer weight, 24.85 g) for Sample J, more than a 2.6-fold increase.

Referring to Table 7, Sample K had a transfer rate to the storage layer of about 2.06 g/min compared to 0.78 g/min for Sample J, more than a 2.6-fold increase. The flux through the distribution material for Sample K was 3.15 g/min/cm² compared to 1.83 g/min/cm² for Sample J, more than a 1.7-fold increase.

These results demonstrate the effectiveness of the distribution layer of the invention to continue to absorb liquid long after initial liquid insult, to absorb greater quantities of liquid, and to transfer acquired liquid to a storage core.

The performance characteristics of liquid distribution for absorbent constructs including a representative distribution layer and adjacent airlaid storage layer (Samples M, N, O, and P) are summarized in Table 9. Also included in Table 9 are characteristics of representative distribution layers alone (Samples Q, R, S, and T) and the storage layer alone (Samples U and V). In each instance, the distribution layer was placed in liquid communication with an airlaid storage layer (i.e., basis weight about 550 gsm; 70 percent by weight superabsorbent material from BASF and 30 percent by weight fluff wood pulp fibers commercially available from Weyerhaeuser under the designation NB416) and contacted with liquid according to the Pressurized Vertical Wicking (PVW) Testing Procedure described below. Samples M-P include the storage layer noted above and a distribution layer composed of a refined blend of polyacrylic acid crosslinked cellulosic fibers (85 percent by weight based on the total weight of the layer), refined southern pine fibers (10 percent by

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weight based on the total weight of the layer), and hardwood fibers (5 percent by weight based on the total weight of the layer). The physical characteristics of Samples M-V are summarized in Table 8.

Table 8. Absorbent Structure Physical Characteristics.

Sample	PVW pressure	Distribution Layer Basis Weight (gsm)	Distribution Layer Weight (g)	Distribution Material Caliper (mm)	Sample Weight (g)
M	0.3	200	4.20	1.73	15.27
N	0.3	97	2.03	0.89	13.73
O	0.5	95	1.99	1.99	13.51
P	0.5	194	4.08	1.69	15.29
Q	0.3	204	4.28	1.63	4.28
R	0.3	112	2.36	0.90	2.36
S	0.5	96	2.01	0.87	2.01
T	0.5	193	4.06	1.69	4.06
U	0.3	--	--	--	11.46
V	0.5	--	--	--	11.68

The characteristics of liquid distribution from representative distribution layers to adjacent airlaid storage layers in Samples M-V are summarized in Table 9. In Table 9, the Absorption Work Integral (AWI) is the sum of the products of the fluid retained in a section multiplied by the height of that section above the fluid reservoir (see PVW Test description below), that is, in integral form, the work done on the fluid by the structure at the end of the experiment (units: g-cm). The Absorption Work Ratio (AWR) is the ratio of a first AWI to a second AWI. Referring to Table 9 below, the last column is the AWR of the ratio of AWI (storage layer plus distribution layer): AWI (storage layer only). The AWR describes the quantitative benefit of having the distribution layer combined with the storage layer.

Table 9. Absorbent Structure Absorption Properties.

	Fluid Absorbed in 30 min.		30 min. Absorption Rate		Instantaneous Absorption Rate @ 30 min.		Fluid Absorbed over Core only	Core normalized by Distrib. Matl.	Fluid Retained in Distrib. Matl.	30 min. Transfer Rate to Core	30 min. Flux thru Distrib. Material	Core Absorpt. Work Integral	Total Absorpt. Work Integral	Core Absorpt. Work Ratio
	g	g/g	g/min	g/g/min	g/min	g/g/min								
M	142.0	9.3	4.7	0.31	0.81	0.05	41.8	9.94	17.68	0.80	0.80	862	981	1.98
N	139.6	10.2	4.6	0.34	1.94	0.14	39.4	19.38	8.09	1.04	1.47	753	805	1.73
O	114.8	8.5	3.8	0.28	1.03	0.08	41.2	20.69	6.78	1.15	1.54	618	657	1.76
P	139.2	9.1	4.6	0.30	1.01	0.07	65.6	-	15.02	1.69	129	711	806	2.03
Q	38.9	9.1	1.3	0.30	0.01	0.00	--	--	19.22	--	--	0	132	--
R	14.2	6.0	0.5	0.20	0.10	0.04	--	--	10.09	--	--	0	79	--
S	13.5	6.7	0.04	0.22	0.11	0.05	--	--	10.73	--	--	0	93	--
T	20.6	5.1	0.7	0.17	0.08	0.02	--	--	19.49	--	--	0	150	--
U	100.2	8.7	3.3	0.29	2.15	0.19	--	--	--	--	--	436	436	1.00
V	73.6	6.3	2.5	0.21	0.69	0.06	--	--	--	--	--	351	351	1.00

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The results summarized in Table 9 demonstrate that the distribution layers of the invention when combined with a storage layer (1) provide the capacity to absorb large quantities liquid over a period of time (between about 115 g and about 145 g over 30 min); (2) provide significant liquid absorption rates after 30 minutes of liquid contact
5 (between about 3.8 and about 4.7 g/min); (3) provide core absorption work integral (AWI) between about 600 and about 900 g-cm; (4) provide total absorption work integral between about 650 and about 1000 g-cm; and (5) provide a core absorption work ratio between about 1.7 and about 2.0.

The distribution layer of the invention, when combined with a storage core,
10 provides an absorbent construct having an absorption rate at 30 minutes greater than about 4.0 g/min. In one embodiment, the construct has an absorption rate at 30 minutes greater than about 4.5 g/cm.

The distribution layer of the invention, when combined with a storage core, provides an absorbent construct having an Absorption Work Integral (total) greater than
15 about 500 g-cm. In one embodiment, the construct has an Absorption Work Integral (total) greater than about 650 g-cm. In another embodiment, the construct has an Absorption Work Integral (total) greater than about 800 g-cm. In one embodiment, the construct has an Absorption Work Integral (total) greater than about 1000 g-cm.

The distribution layer of the invention, when combined with a storage core,
20 provides an absorbent construct having an Absorption Work Ratio greater than about 1.1. In one embodiment, the construct has an Absorption Work Ratio greater than about 1.5. In another embodiment, the construct has an Absorption Work Ratio greater than about 1.7. In another embodiment, the construct has an Absorption Work Ratio greater than about 2.0.

25 The characteristics of representative distribution layers in combination with a commercially available diaper core (PAMPERS) are summarized in Tables 10 and 11 in FIGURES 15 and 16. In these constructs, the PAMPERS core includes an airlaid storage layer containing about 40 percent by weight absorbent material partially wrapped with a tissue. Tissue wraps one major surface of the core, all edges of the core, and a portion of
30 the second major surface. The distribution layer of the invention was placed adjacent the second major surface of the core. Referring to Table 10, the absorption rate of the constructs including the distribution layer had significantly greater rates (3.32 to 3.54

-32-

g/min) compared to the control construct without a distribution layer (2.85 g/min). As demonstrated by the results in Tables 10 and 11, the constructs including the distribution layer had improved performance compared to the commercial product.

The distribution layer of the invention can be combined with one or more storage layers or cores in an absorbent construct. For example, a construct can include (1) a full distribution layer and a full core; (2) a half core, a full distribution layer, and a half core; (3) a half distribution layer, a full core, and a half distribution layer; and (4) a half core, half distribution layer, half core, and half distribution layer. The characteristics of such absorbent constructs are summarized in Tables 12 and 13 in FIGURES 17 and 18. Referring to Table 13, the transfer to core at 60 minutes for these constructs was from 1.11 to 1.33 g/min/g distribution layer.

As described above, the distribution layer effectively transfers acquired liquid to an adjacent storage core. The characteristics of liquid transfer to a storage core where only the distribution layer is in contact with the fluid reservoir in the PVW apparatus (see below) are summarized in Table 14 in FIGURE 19.

Pressurized Vertical Wicking (PVW) Test

The liquid transfer rate performance of absorbent structures can be evaluated using the Pressurized Vertical Wicking (PVW) Test as described below. In the test, a pressurized vertical wicking apparatus is used to measure the liquid transfer rate performance of absorbent composite structures under different loading, for example, from about 0.02 to about 0.5 psi.

The apparatus for pressurized vertical wicking testing is illustrated in FIGURES 14A-E. Referring to FIGURES 14A-E, apparatus 300 includes an acrylic pressure box 302 with front side 304 formed by latex membrane 306 that is sealed to outer edge 308 on all four sides of the box. Faceplate 310 latches to the front of box 302 so that a sample (e.g., combination of distribution layer 10 and storage layer 20) can be positioned between membrane 306 and faceplate 310. The top and bottom edge of the box have a 10-13 cm wide by 1 cm deep slot 312 to allow the sample to extend above and below the pressure area between faceplate 310 and membrane 312. A separate air pressure supply

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hose 314 and air regulator 316 are connected to the pressure box to set and maintain a stable pressure within the apparatus.

The external dimensions of the pressure box are 22 cm (h) by 22 cm (w) by 13 cm (d). The internal dimensions of the pressure box are 20 cm (h) by 20 cm (w) by 12 cm (d). This allows for testing samples that are equivalent to the front or back half of a size 4 infant diaper.

Typically the distribution layer sample is cut to 5-10 cm wide by 21 cm long. The first cm of the sample is immersed in the testing fluid, 0.9% NaCl saline solution. The storage core sample is cut to 10 cm wide by 10-21 cm long, depending upon its capacity and whether it is immersed in the saline solution. Permanent markers are used to draw lines across the width of the test samples at 1 cm and every 2.5 cm. If the core is not immersed then only 2.5 cm lines are drawn. At the end of the test the first cm is cut off and discarded. The remainder of the sample is sectioned at the 2.5 cm marks. Each section is weighed and the mass of fluid in each section along with the total mass absorbed are determined.

Test strips of distribution layer and storage core are weighed and the caliper is measured. The basis weight and density are then determined. Typically the storage core is placed on the membrane without any part extending above or below the pressure zone - area between the membrane and faceplate. The distribution layer is aligned with the storage core so that 1 cm of the distribution layer extends below the bottom of the pressure box and the sample is aligned with the top and bottom slots. The faceplate is attached and a predetermined air pressure (0.02-0.5 psi) enters the box, forcing the membrane against the sample and the faceplate. Reservoir 318 containing 0.9% saline solution is placed on electronic balance 320 that is connected to computer 322 for acquiring mass verses time data. The pressure box is suspended above the reservoir so only the bottom cm of sample is in the fluid. Data acquisition is started when the sample first contacts the fluid. The mass of fluid absorbed into the sample is recorded every 5 seconds and the test continues for 60 minutes. At the end of the 60 minutes the data acquisition is stopped and the sample is removed from the fluid. Air pressure is removed from the box and the sample is sectioned and weighed. The absorption work integral

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(AWI) is calculated by multiplying the weight of fluid in each section by the section length by the height of the midpoint of the section above the reference point. The total of all the sections at height and weight is the total absorption work integral. Other calculated values are 60 minute transfer rate, total fluid absorbed, maximum absorption rate, smoothed maximum rate, smoothed average rate, time to absorb 25, 50, 75, 100 and 150 g of fluid, and the rate to absorb each mass of fluid.

In summary, the layer of the invention effectively distributes acquired liquid to an associated storage layer. The effective distribution allows for the full utilization of the absorbent capacity of the storage layer. In performing its distribution function, the layer avoids the problem of leakage of a personal care absorbent product resulting from the product's inability to fully and rapidly take up liquid discharged into the product. In performing its distribution function, the layer effectively distributes liquid to an associated storage layer remote from the site of liquid insult thereby avoiding the problem of leakage resulting from liquid saturation of a storage core in the vicinity of liquid insult. Absorbent products having relatively thin and narrow designs are particularly susceptible to leakage and benefit the greatest from the advantages of the distribution layer of the invention. Again, through effective distribution of acquired liquid, the layer provides for the utilization of an associated storage layer's full absorbent capacity thereby avoiding excessive bulkiness and discomfort that result from a locally saturated storage layer. Furthermore, because the layer effectively transfers acquired liquid to an associated storage layer, the distribution layer of the invention has the advantageous property of being able to acquire, distribute, and ultimately transfer liquid acquired from successive insults. Because the distribution layer of the invention advantageous provides rapid liquid uptake, distribution, and release to an associated storage layer, both initially and on successive liquid insults, the layer is particularly well suited for incorporation into personal care absorbent products, such as infant diapers, training pants, and incontinence products, to provide improved absorbent products.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A fibrous layer, which when in liquid communication with a storage layer, provides an absorbent construct having an Absorption Work Ratio greater than about 1.1
2. The layer of Claim 1, comprising a refined blend of crosslinked cellulosic fibers and noncrosslinked cellulosic fibers.
3. The layer of Claim 2, wherein the crosslinked cellulosic fibers are present in an amount from about 50 to about 90 percent by weight based on the total weight of the layer.
4. The layer of Claim 3, wherein the crosslinked cellulosic fibers are present in an amount from about 75 to about 90 percent by weight based on the total weight of the layer.
5. The layer of Claim 4, wherein the crosslinked cellulosic fibers are present in about 85 percent by weight based on the total weight of the layer.
6. The layer of Claim 5, wherein the noncrosslinked cellulosic fibers are present in an amount from about 10 to about 50 percent by weight based on the total weight of the layer.
7. The layer of Claim 6, wherein the noncrosslinked cellulosic fibers are present in an amount from about 10 to about 25 percent by weight based on the total weight of the layer.
8. The layer of Claim 7, wherein the noncrosslinked cellulosic fibers are present in about 15 percent by weight based on the total weight of the layer.
9. The layer of Claim 8, wherein the noncrosslinked cellulosic fibers comprise southern pine fibers.

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10. The layer of Claim 9, wherein the noncrosslinked cellulosic fibers comprise hardwood fibers.

11. An absorbent construct, comprising a distribution layer in liquid communication with a storage layer; wherein the construct has an Absorption Work Ratio greater than about 1.1.

12. The construct of Claim 11, wherein the distribution layer comprises a refined blend of crosslinked cellulosic fibers and noncrosslinked cellulosic fibers.

13. The construct of Claim 12, wherein the crosslinked cellulosic fibers are present in an amount from about 50 to about 90 percent by weight based on the total weight of the layer.

14. The construct of Claim 12, wherein the noncrosslinked cellulosic fibers are present in an amount from about 10 to about 50 percent by weight based on the total weight of the layer.

15. The construct of Claim 11, wherein the storage layer comprises absorbent material.

16. The construct of Claim 11, wherein the storage layer comprises an airlaid fibrous cellulosic layer.

17. An absorbent article, comprising the layer of Claim 1.

18. An absorbent article, comprising the construct of Claim 11.

19. The absorbent articles of Claims 17 or 18, wherein the article is at least one of an infant diaper, a training pant, and an adult incontinence product.

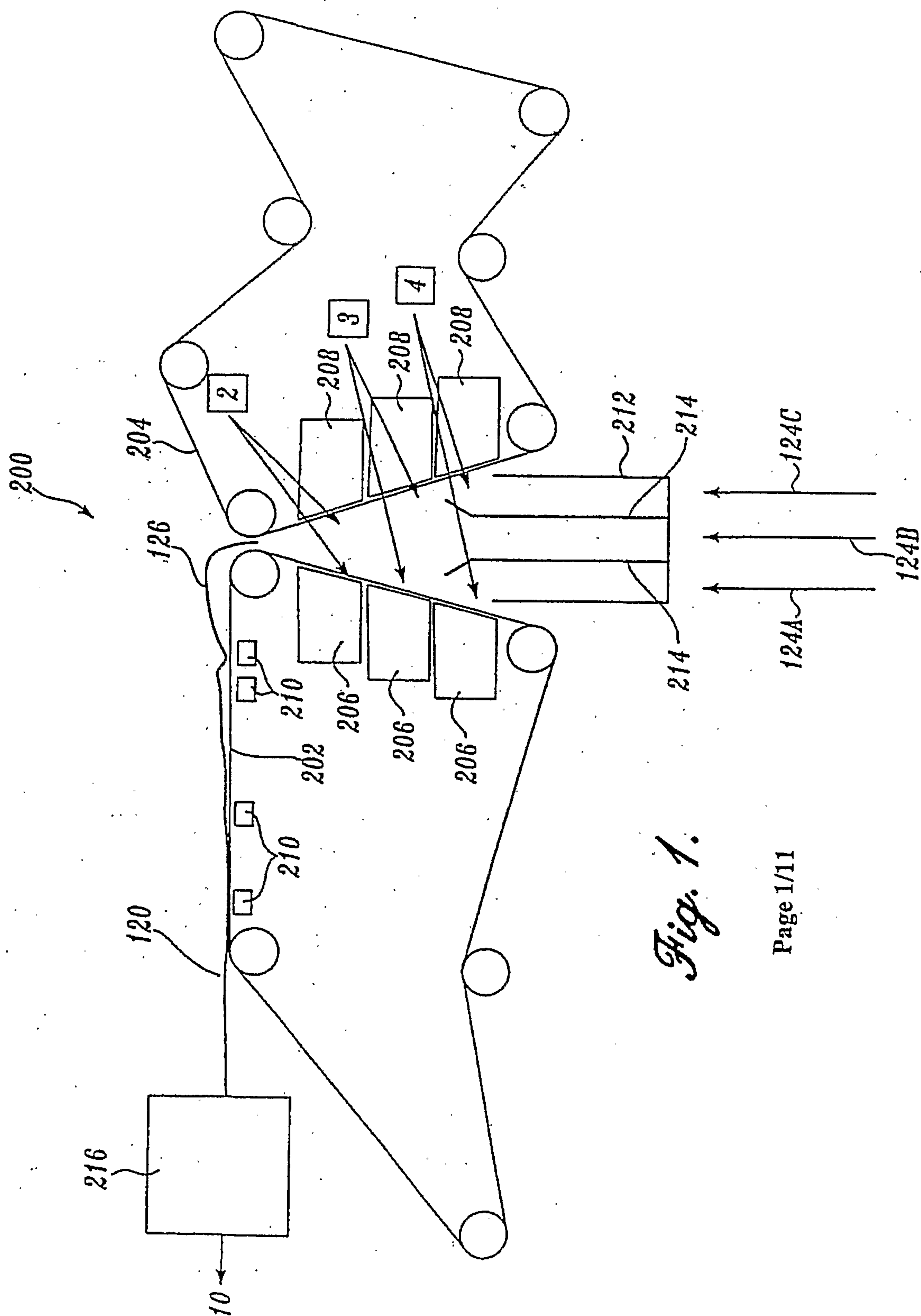


Fig. 1.

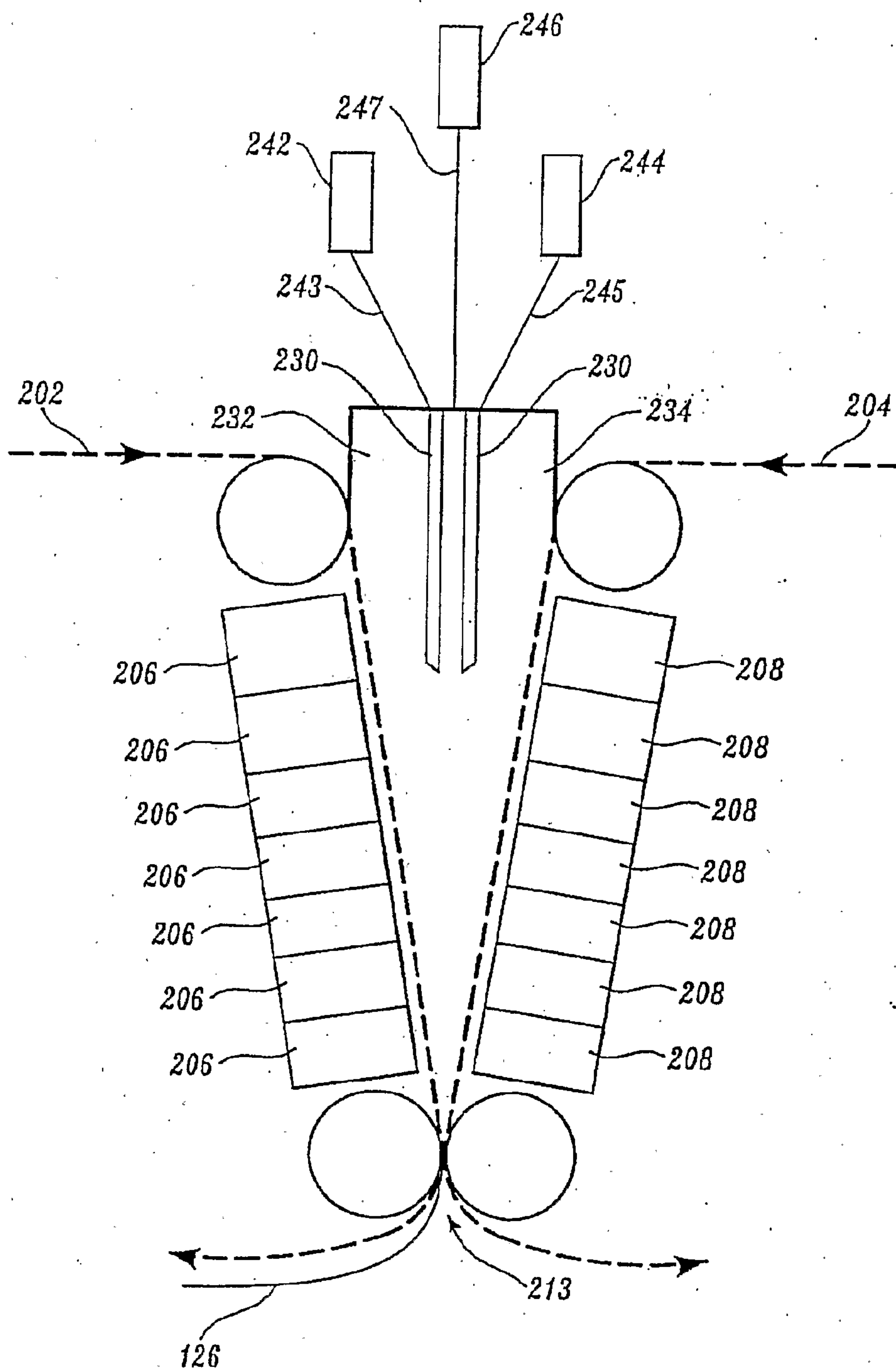
*Fig. 2.*

FIGURE 3

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1049-XNP-2

Wick Time & Tensile vs. Cantilever Stiffness

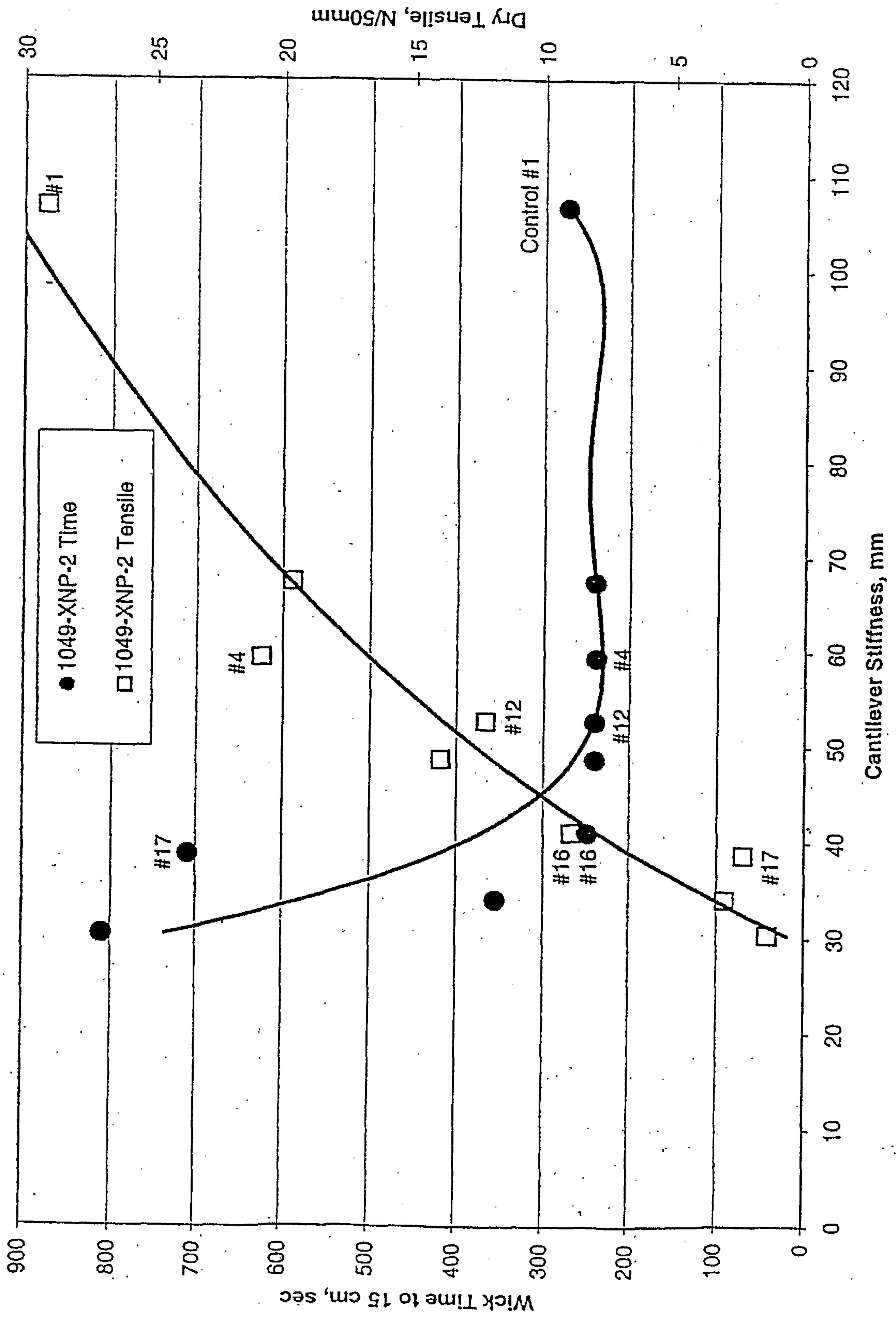


FIGURE 4
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Fluid Transfer to core by time

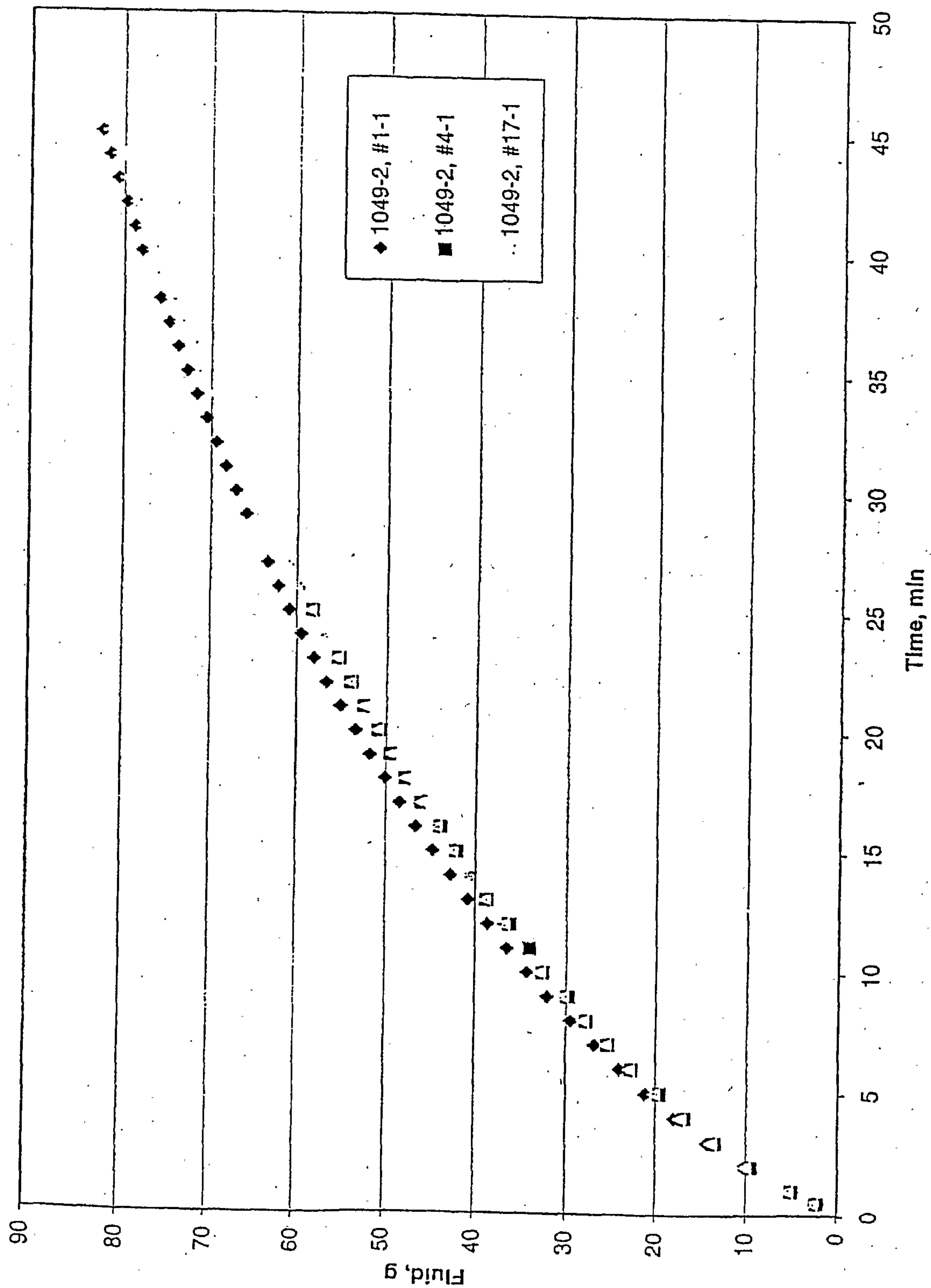


FIG. 5
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Acquisition of Fluid of 4th 75ml Insult
Using Saddle Wicking Apparatus

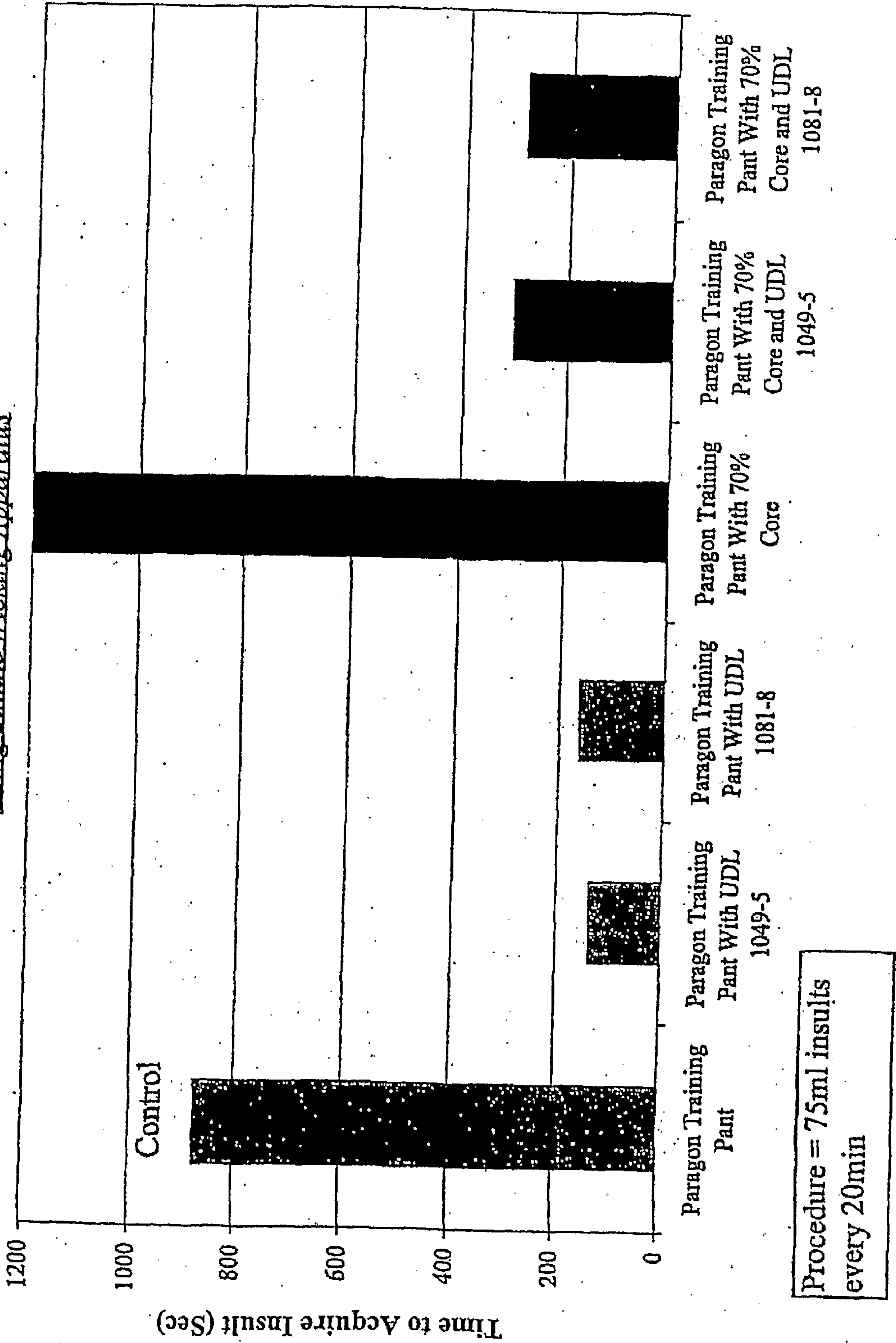
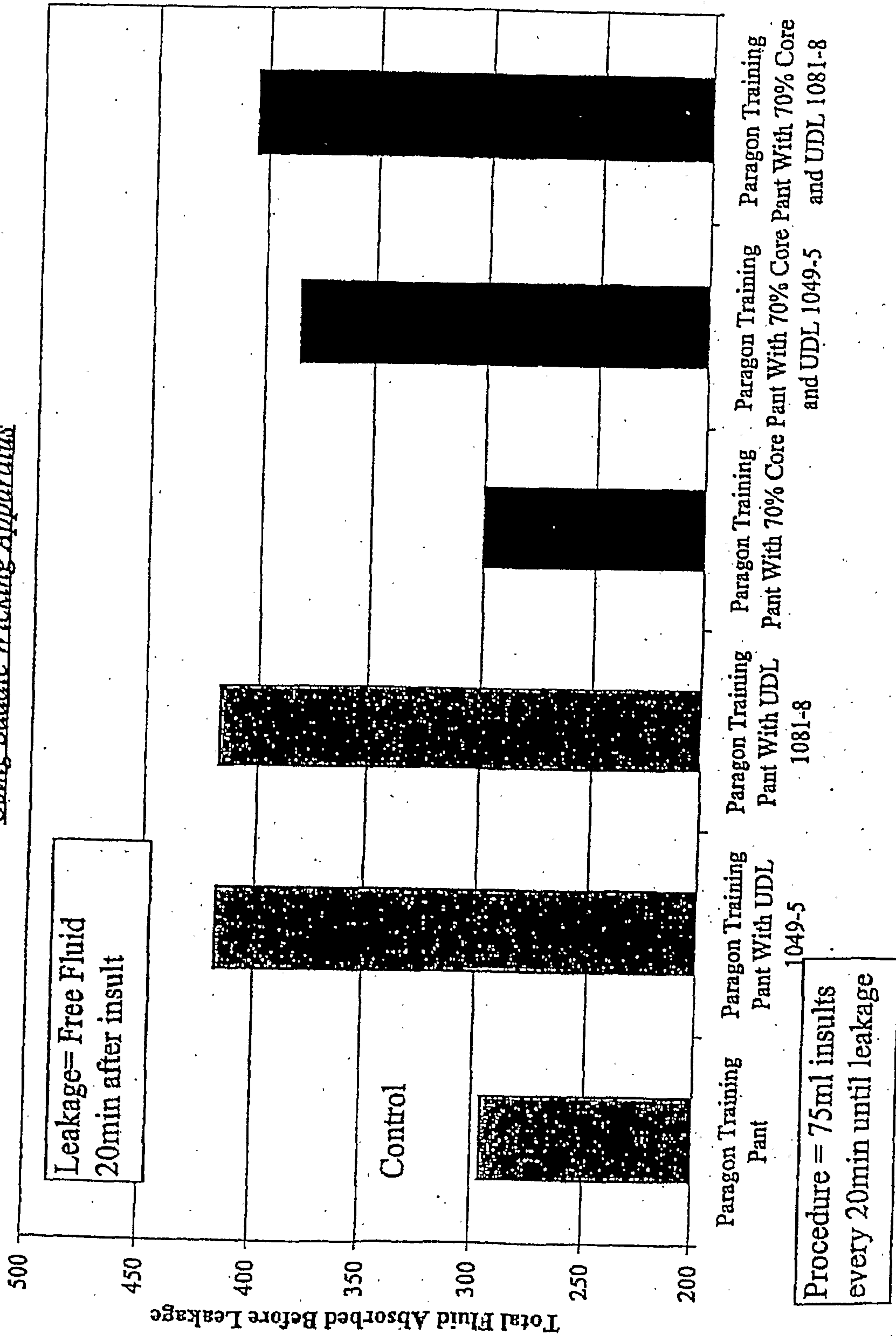


FIG. 6
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Percent of Overall Capacity Utilized Before Leakage
Using Saddle Wicking Apparatus



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FIG. 7
Page 7/11
Distribution of Fluid within Training Pant Using Saddle Wicking Apparatus

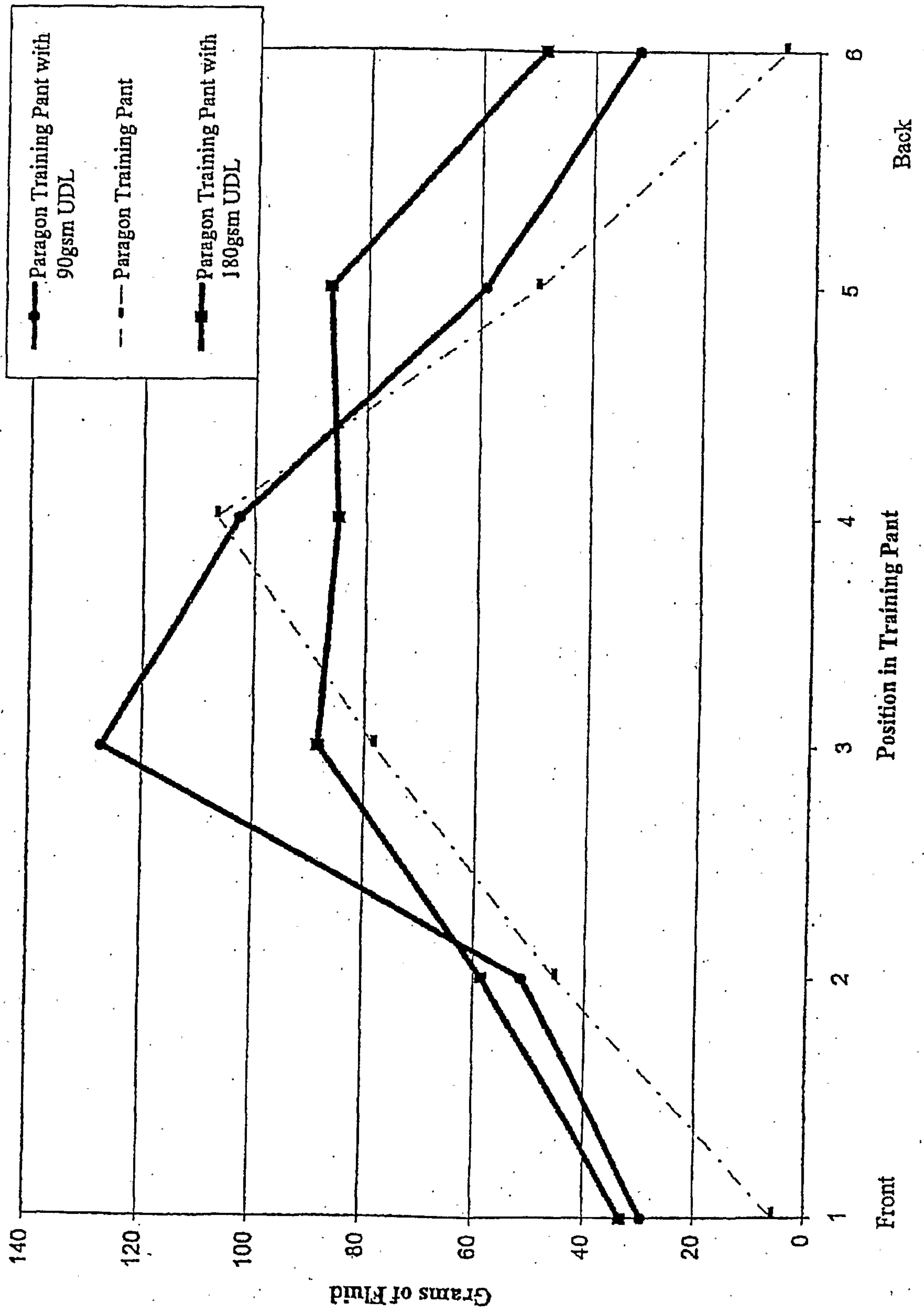


FIG. 8
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Distribution of Fluid within Training Pant Using Saddle Wicking Apparatus

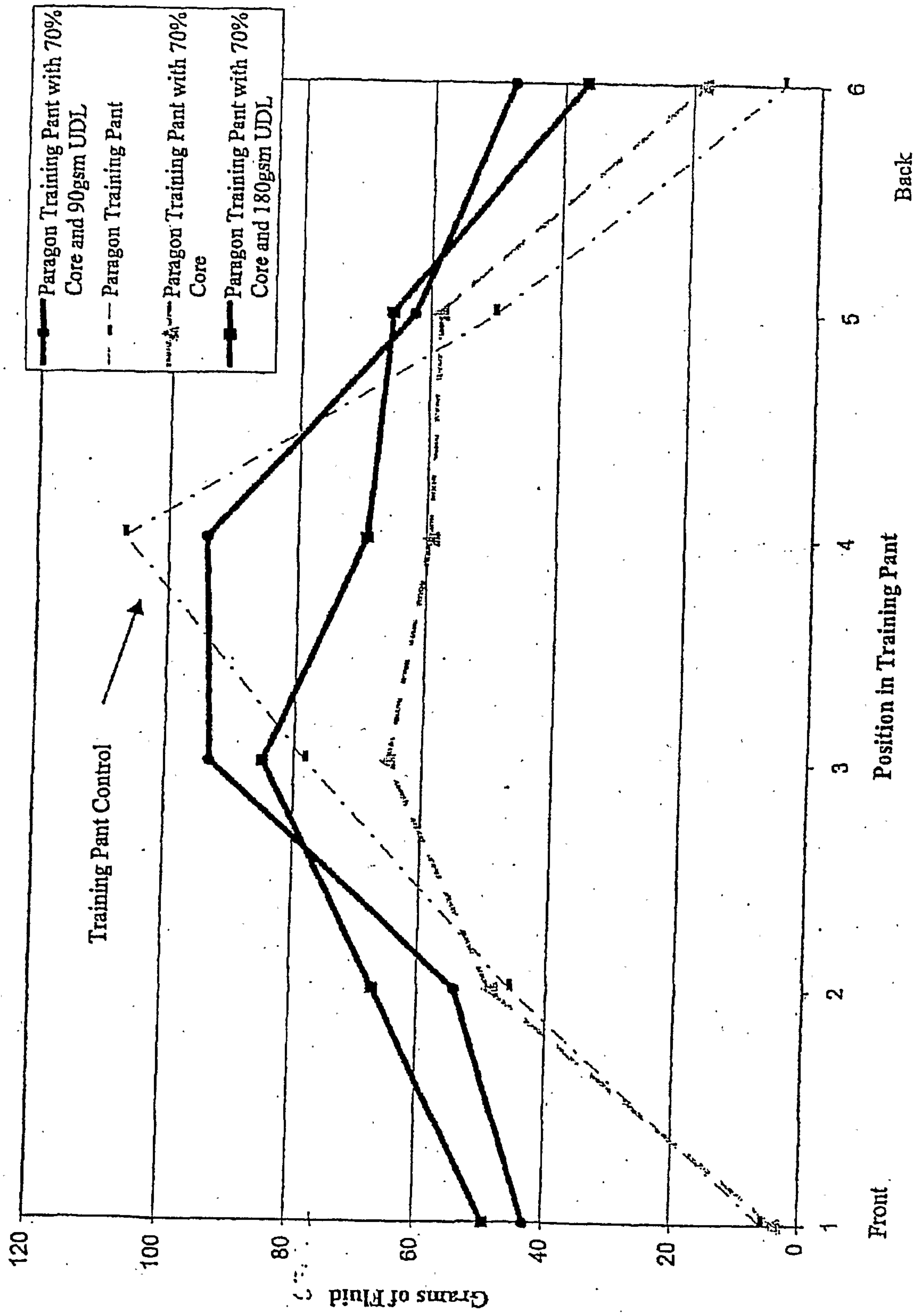


FIG. 9
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Acquisition of Fluid of 3rd 75ml Insult
Using Market Pulp Flat Acquisition Test

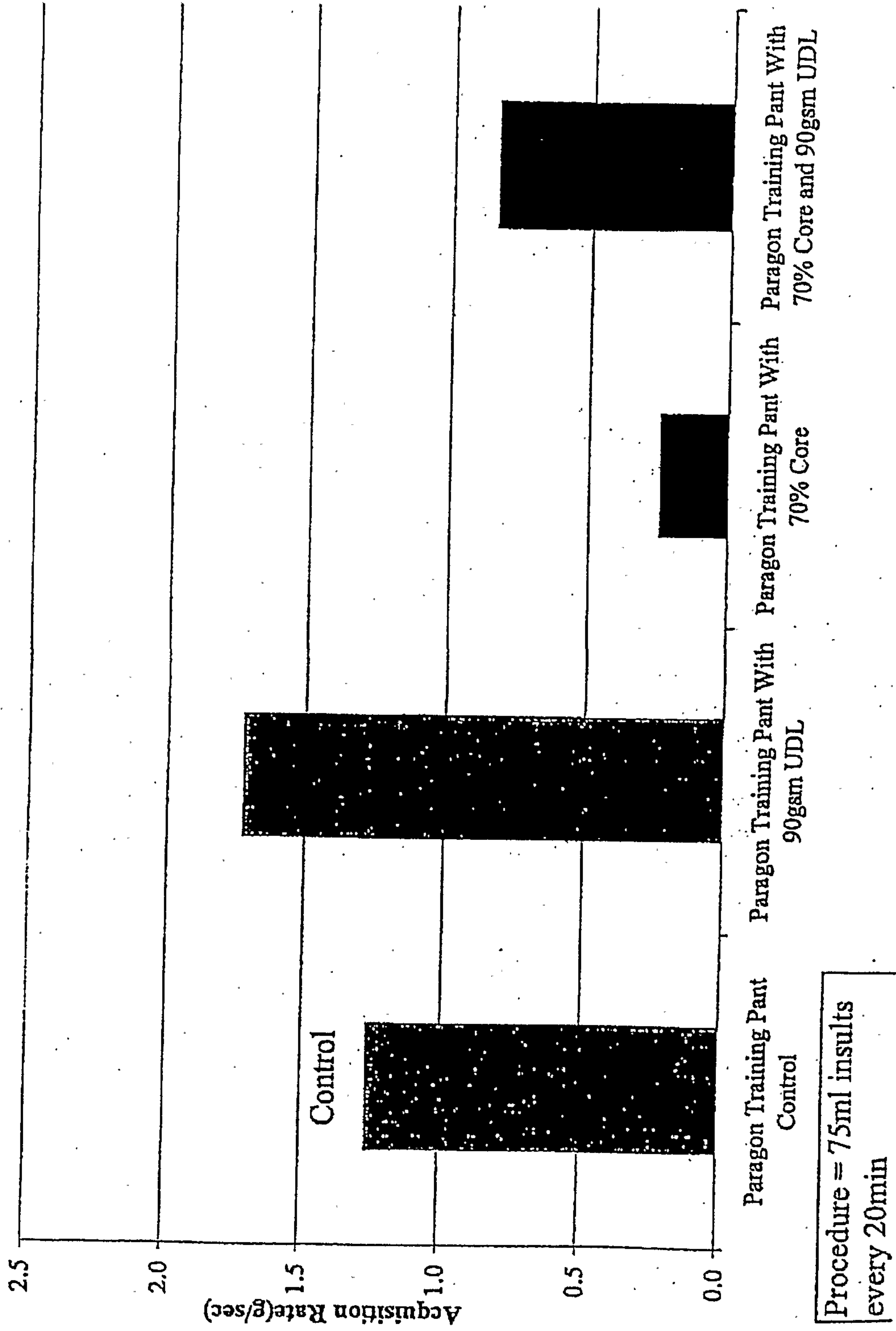


FIG. 10
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Acquisition Rate of Training Pants
Using Market Pulp Flat Acquisition Test

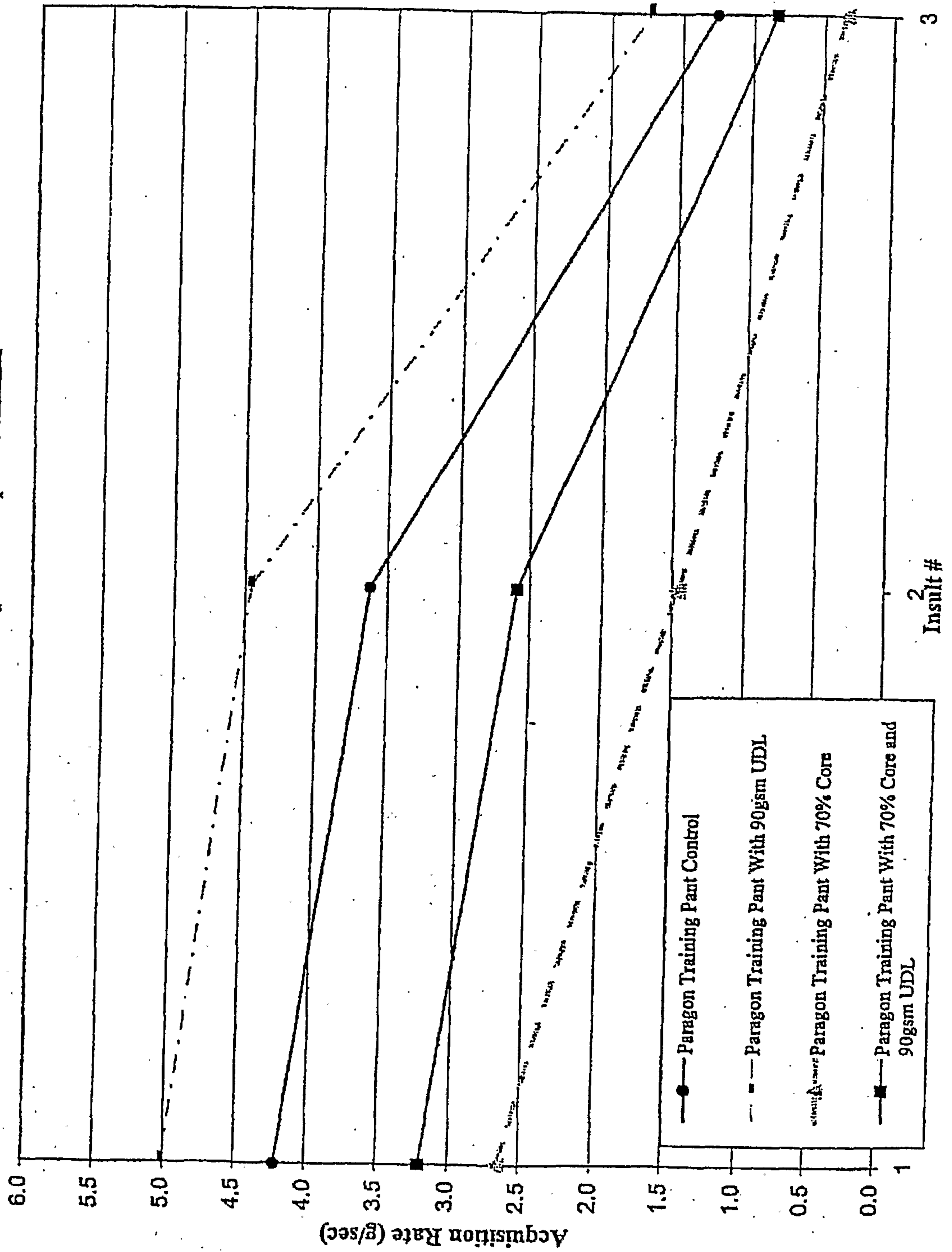
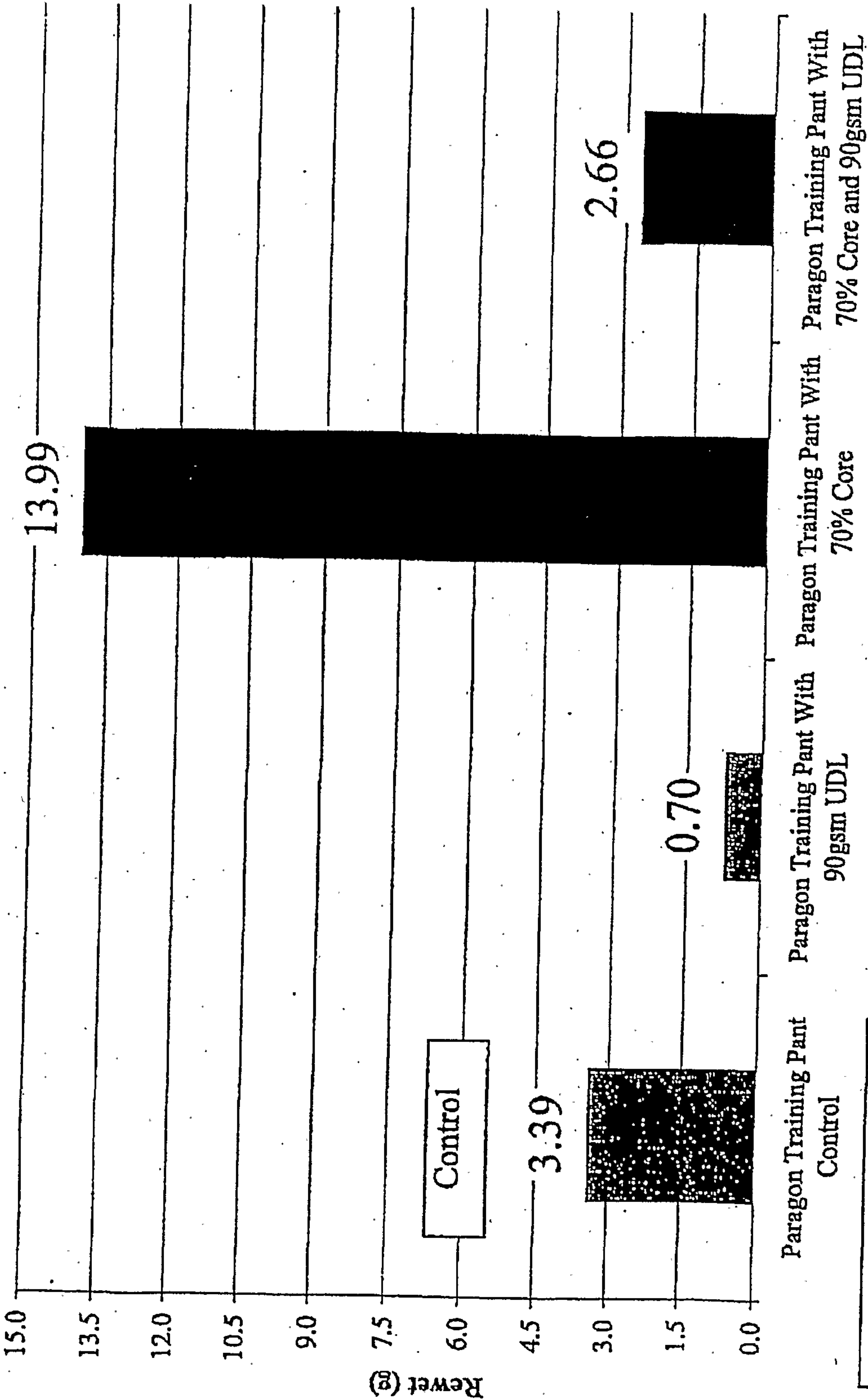
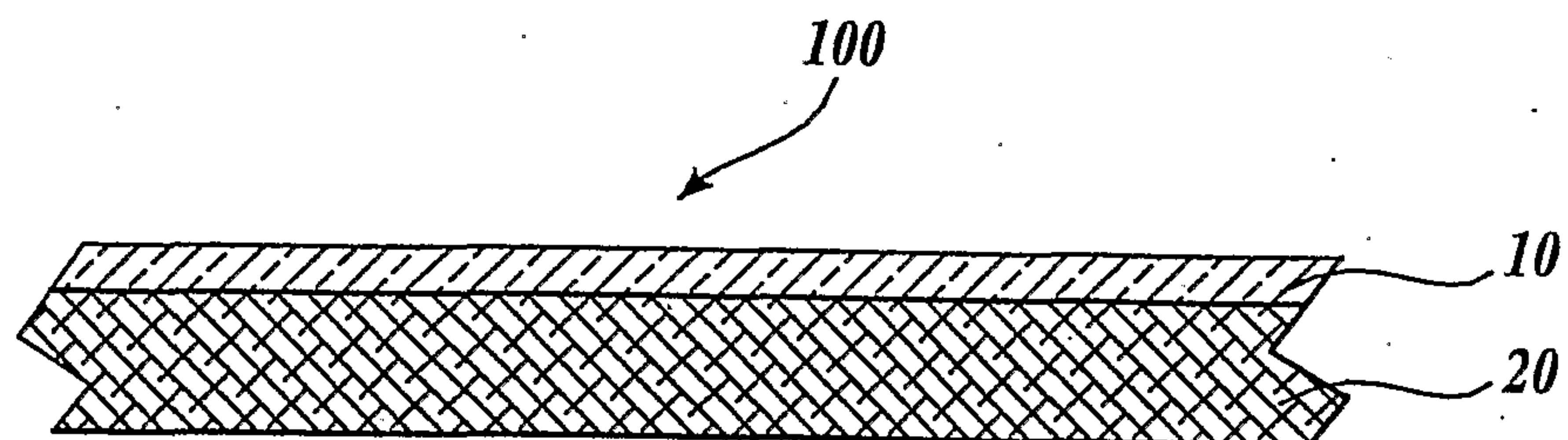
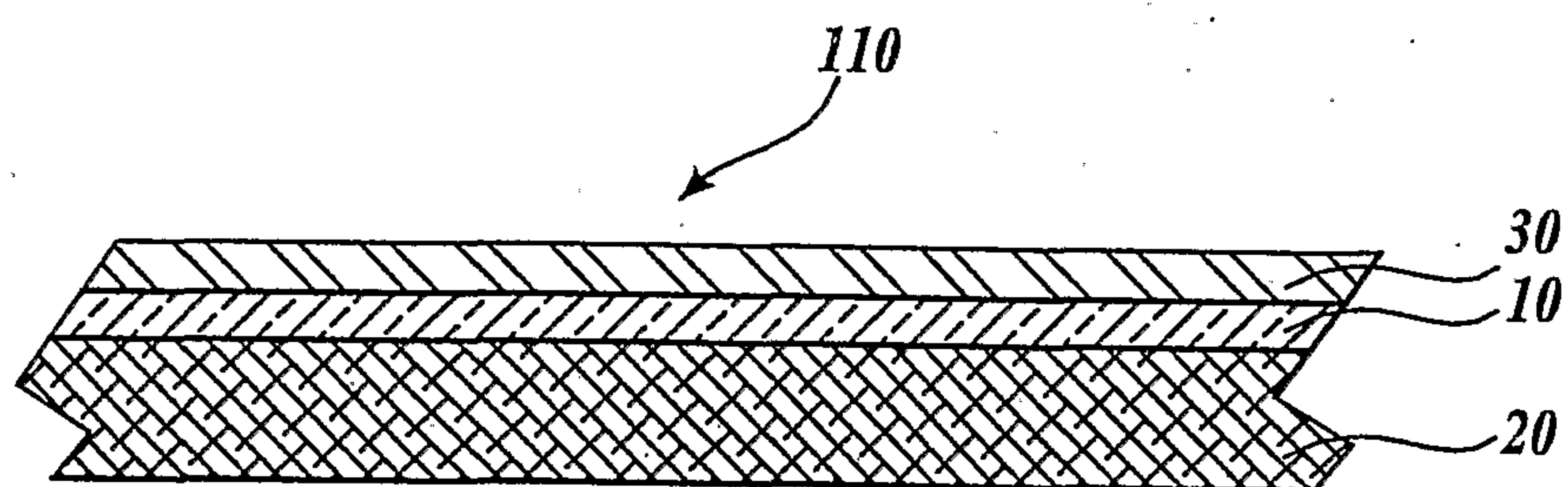
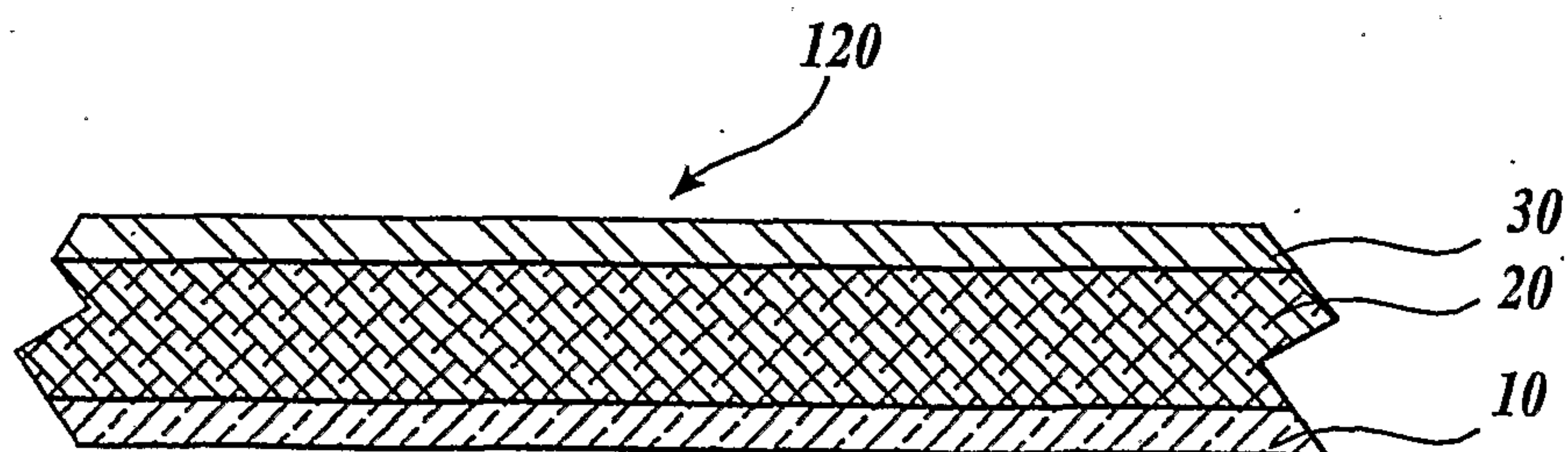


FIG. 11
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*Acquisition of Fluid of 4th 75ml Insult
Using Market Pulp Flat Acquisition Test*



Procedure = 75ml insults
every 20min

*Fig. 12A.**Fig. 12B.**Fig. 12C.*

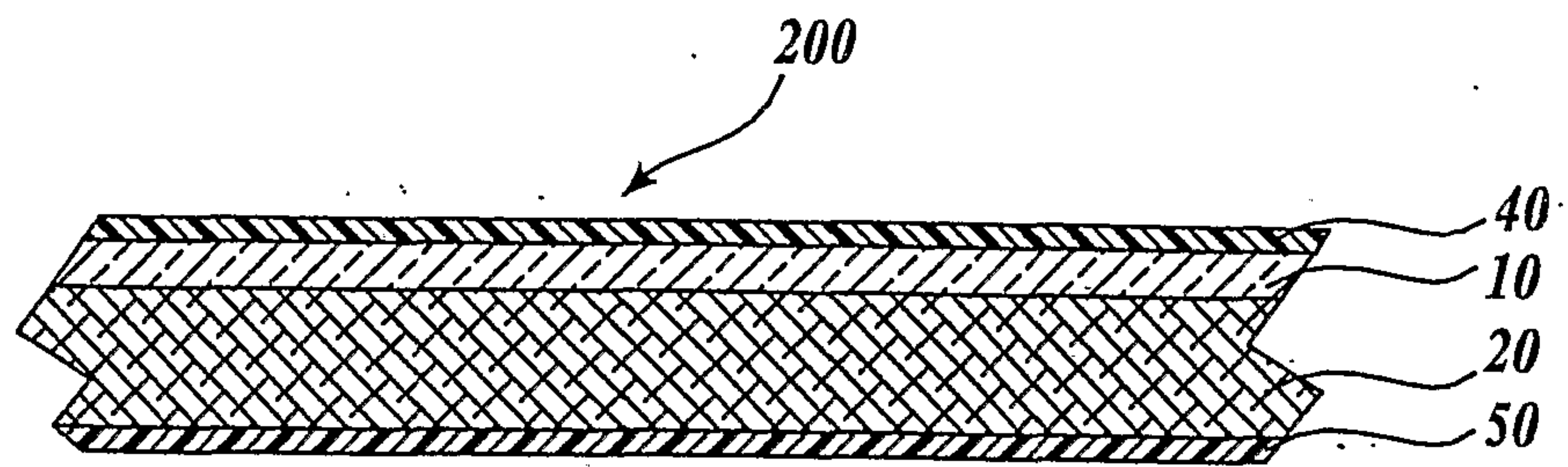
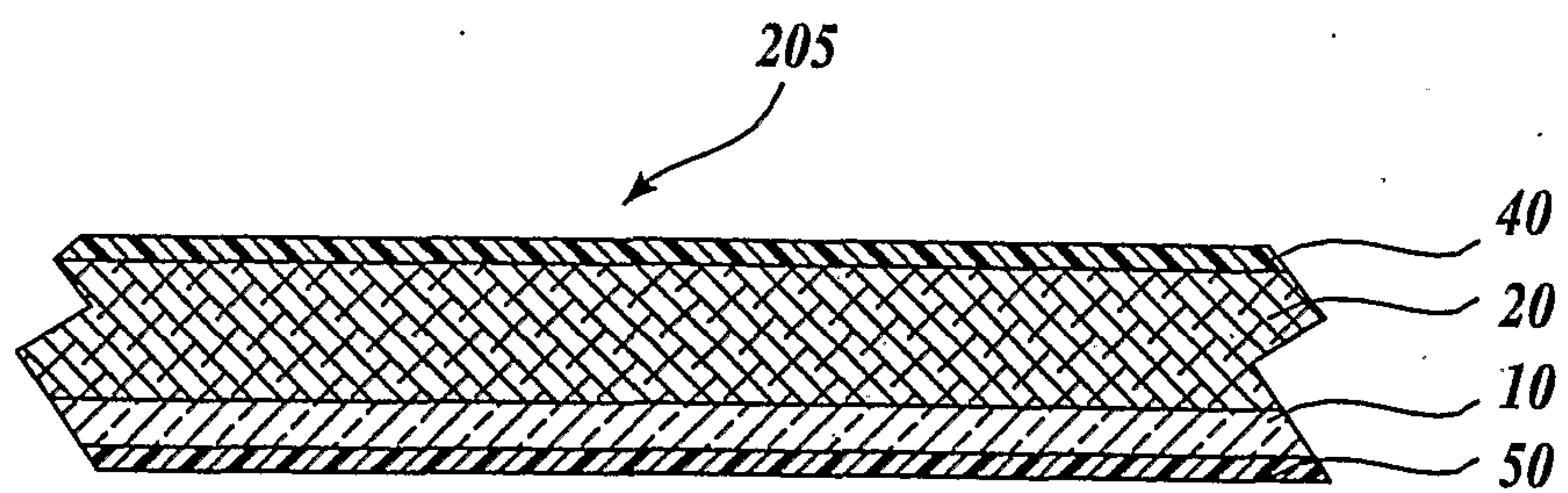
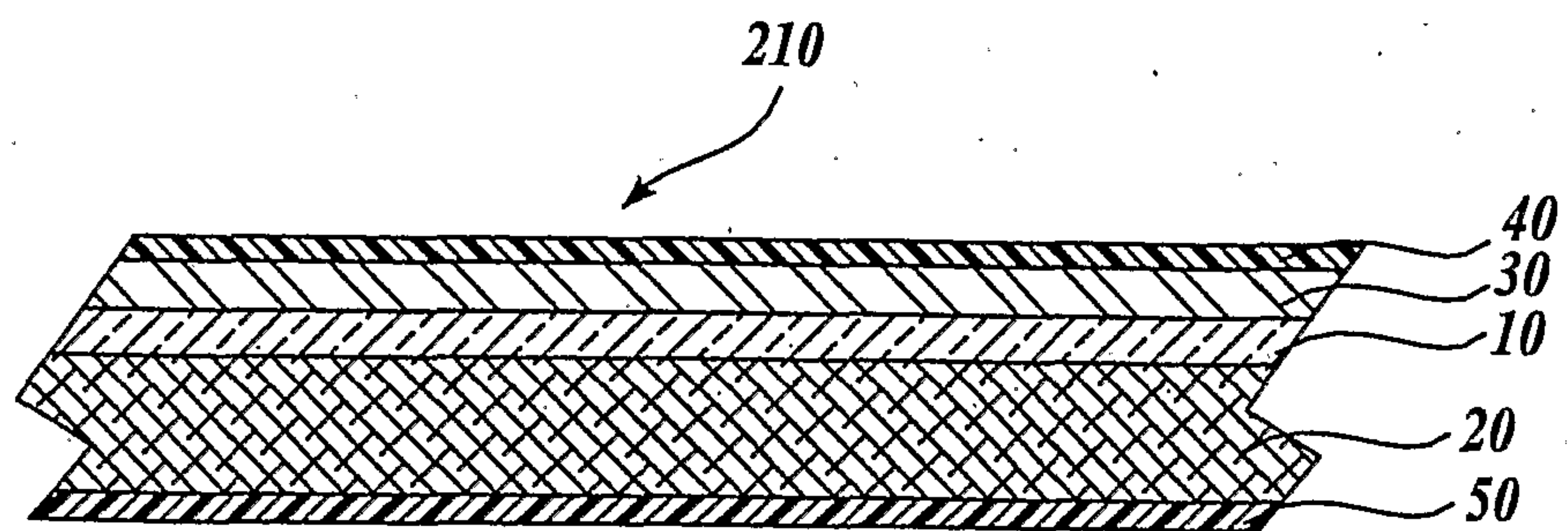
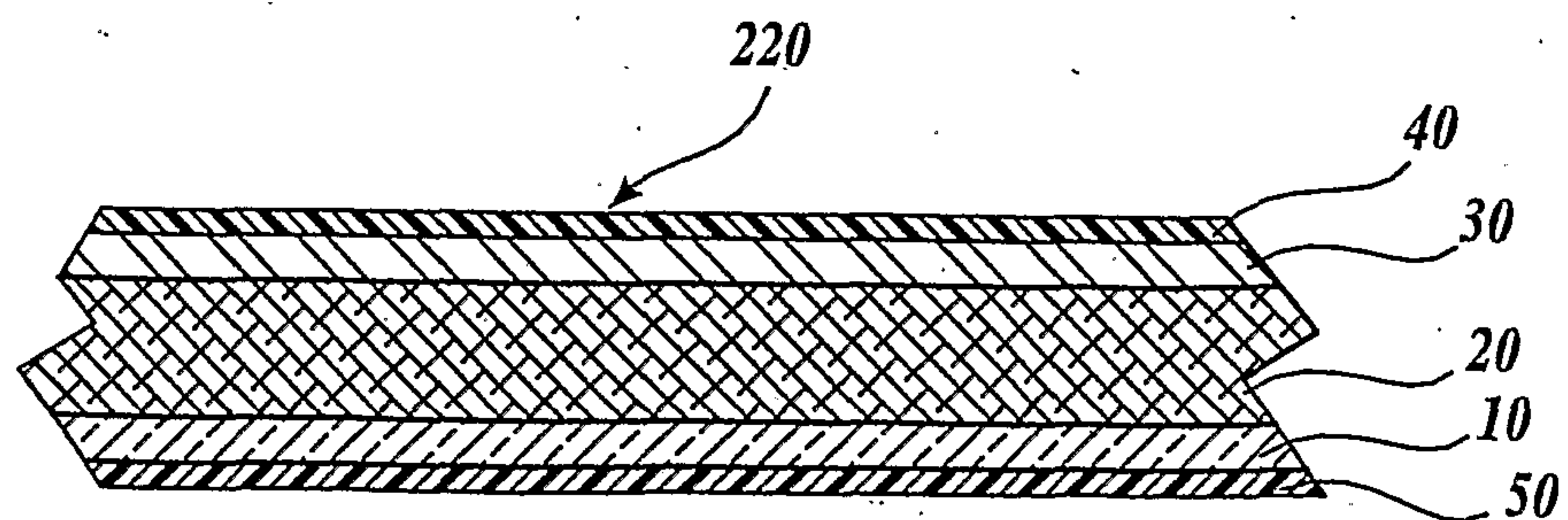
*Fig. 13A.**Fig. 13B.**Fig. 13C.**Fig. 13D.*

FIGURE 14A

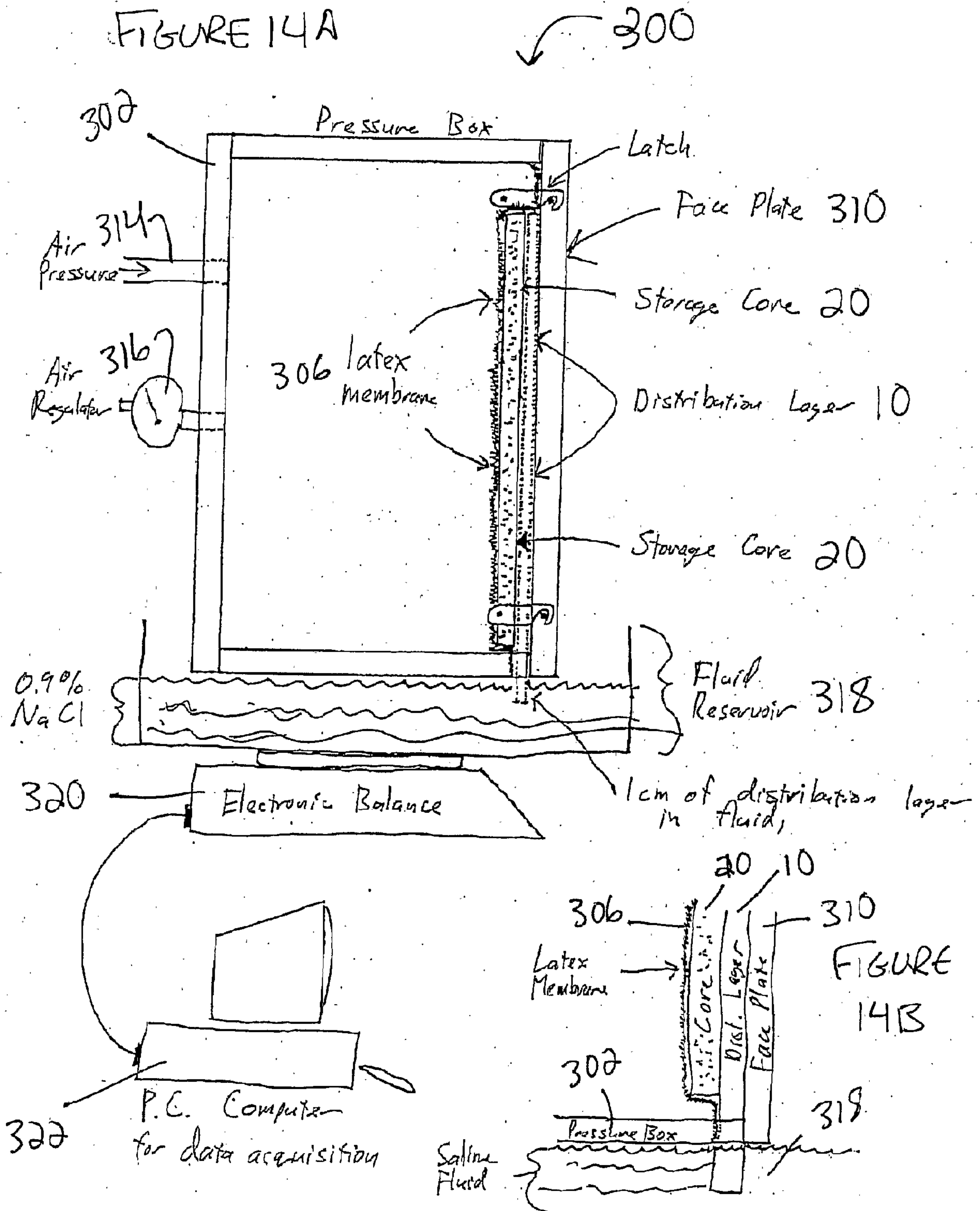
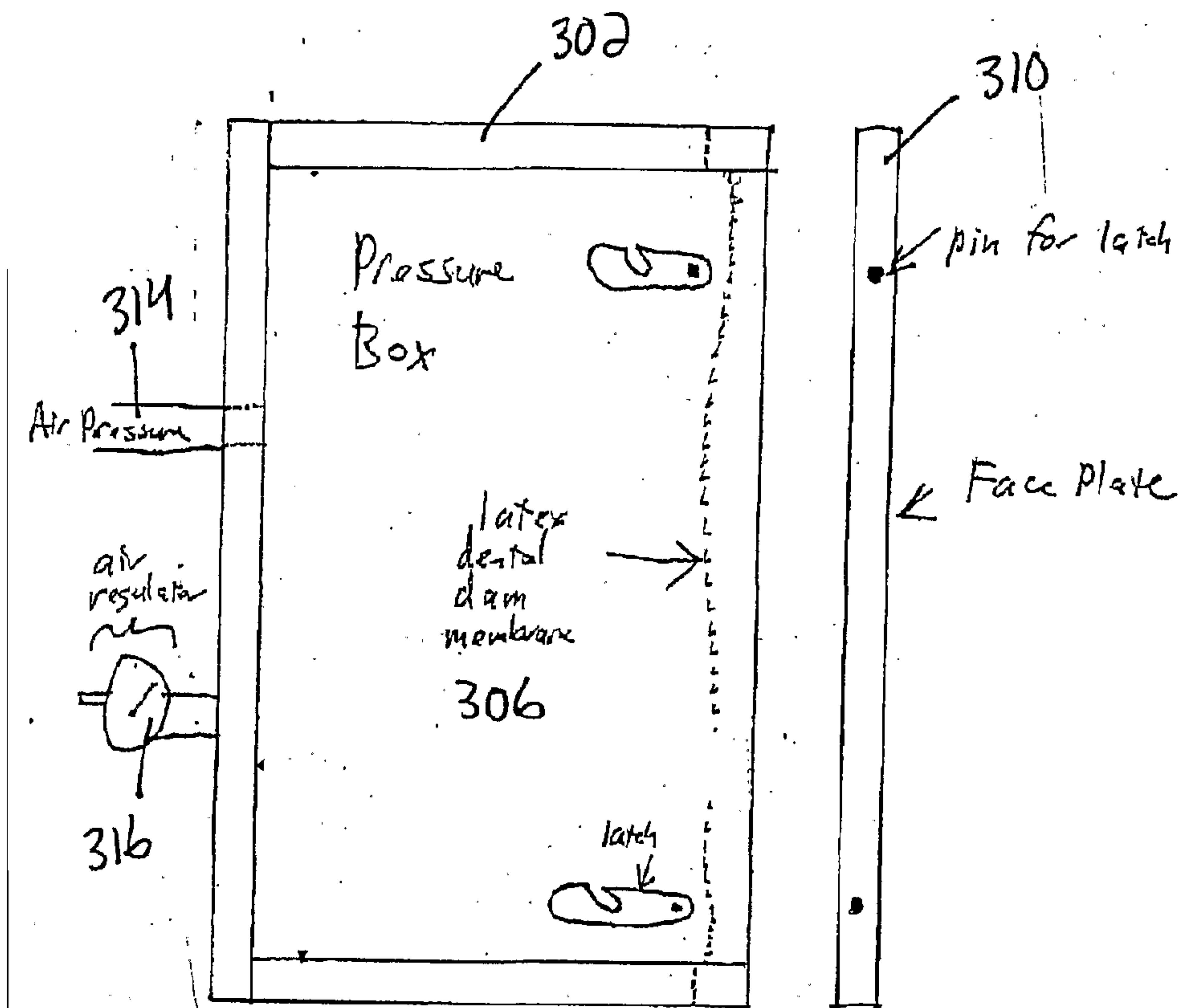


FIGURE
14C

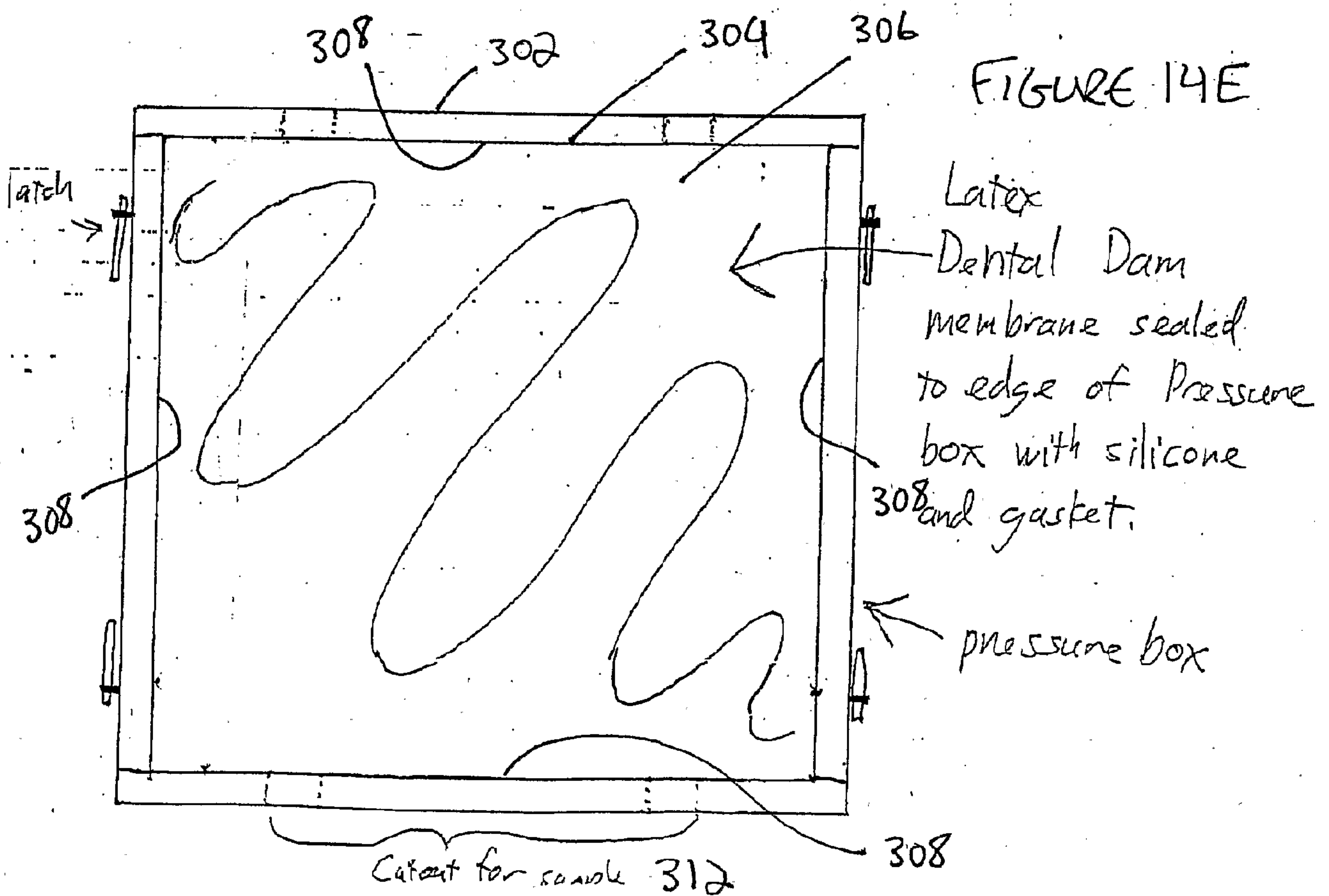
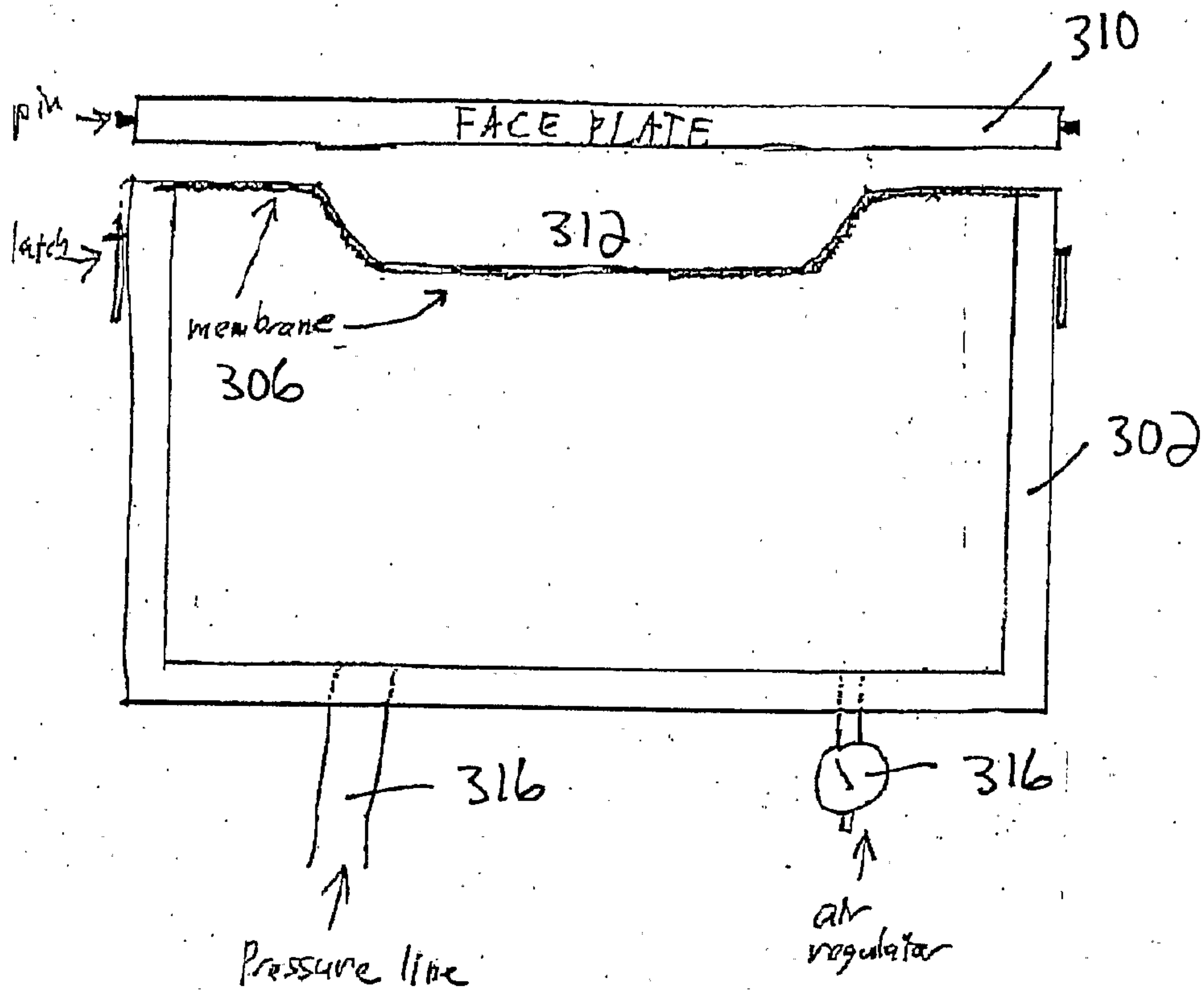


Table 10

Internal Code	Experimental Code	Sample Description	PVW Press.	Tissue Included		Distrib. Material Code	Distrib. Material OD BW gsm	Distrib. Material OD wt. g	Distrib. Material caliber mm	Sample Total OD wt. g	Fluid Absorbed in 60 min.		60 min. Absorption Rate		Absorption Time (min.) to mass:			Absorption Rate (g/min.) to mass:		
				Yes	No						g	g/g	g/min	g/g/min	50 g.	100 g.	150 g.	50 g.	100 g.	150 g.
				Set 1																
4	Pampers Front Alone 0.05 psi	Pampers core, front 1/3, no DL	0.05	Yes		Note				10.45	168.5	16.1	2.85	0.27	0.8	3.6	19.2	62.5	27.8	7.8
6	Pampers Front 1085-2 0.05 psi	Pampers core, front 1/3, 1085-2 UDL	0.05	Yes		1085-XNP-2	89	1.21	0.76	12.33	209.8	17.1	3.54	0.29	0.6	2.4	7.1	83.3	41.7	21.1
9	Pampers Front 1093-1 0.05 psi	Pampers core, front 1/3, 1093-1 UDL	0.05	Yes		1093-XNP-1	88	1.20	1.10	12.38	211.1	17.1	3.54	0.29	0.8	2.7	7.6	66.7	37.0	19.7
10	Pampers Front 1093-2 0.05 psi	Pampers core, front 1/3, 1093-2 UDL	0.05	Yes		1093-XNP-2	56	0.76	0.70	11.41	200.7	17.6	3.37	0.29	0.8	2.6	7.8	66.7	38.5	19.2
11	Pampers Front 1093-4B 0.05 psi	Pampers core, front 1/3, 1093-4B UDL	0.05	Yes		1093-XNP-4B	56	0.76	0.53	11.45	197.8	17.3	3.32	0.29	0.9	2.7	8.3	55.6	37.0	18.1

FIGURE 15

Table 11

Internal code	Experimental Code	Sample Description	PVW Press.	Tissue Included		Fluid Absorbed over Core only	Fluid over Core normalized by Distrib. Matl. Wt.	Fluid Retained In Distrib. Matl.	60 min. Transfer Rate to Core	60 min. Flux thru Distrib. Material	Core Absorption Work Integral	Total Absorption Work Integral	Core Absorpt. Work Ratio
				Yes	No								
	Set 1												
4	Pampers Front Alone 0.05 psi	Pampers core, front 1/3, no DL	0.05	Yes							951	951	
6	Pmp's Front 1085-2 0.05 psi	Pampers core, front 1/3, 1085-2 UDL	0.05	Yes		41.3	34.3	7.14	0.57	83.6	1180	1244	1.24
9	Pmp Front 1093-1 0.05 psi	Pampers core, front 1/3, 1093-1 UDL	0.05	Yes		42.6	35.5	6.16	0.61	59.6	1272	1323	1.34
10	Pmp Front 1093-2 0.05 psi	Pampers core, front 1/3, 1093-2 UDL	0.05	Yes		32.2	42.6	3.43	0.48	70.7	1108	1138	1.17
11	Pmp Front 1093-4 0.05 psi	Pampers core, front 1/3, 1093-4B UDL	0.05	Yes		29.3	38.9	3.71	0.43	85.2	1096	1127	1.15

FIGURE 16

Table 12

Internal code	Experimental Code	Sample Description	PVW Press.	Distrib. Material Code	Distrib. Material OD BW gsm	Distrib. Material OD wt. g	Total Distrib. Material caliper mm	Sample Total OD wt: g	Fluid Absorbed in 60 min. g	60 min. Absorption Rate g/min	Absorption Time (min.) to mass:		Absorption Rate (g/min.) to mass:		
											25 g.	50 g.	25 g.	50 g.	
Layering Configuration															
1	Full Core: Full Dist. Layer	1-512 gsm Core: 60% SAP 40% NB416 + 1-90 gsm DL	0.2	1093-XNP-1	87	1.18	1.09	8.00	98.2	1.65	4.2	12.8	6.0	3.9	2.6
	Half Core: Full Dist. Layer: Half Core	2-256 gsm Cores: 60% SAP 40% NB416 + 1-90 gsm DL													
2	Half Dist. Layer: Full Core: Half Dist. Layer	2-50 gsm DLs + 1-512 gsm Core: 60% SAP 40% NB416	0.2	1093-XNP-2	56 (2)	1.53	1.30	7.96	107.3	1.79	2.9	8.5	8.7	5.9	3.8
4	Half Core: Half Dist. Layer: Half Core: Half Dist. Layer	2-256 gsm Cores: 60% SAP 40% NB416 + 2-50 gsm DLs	0.2	1093-XNP-2	55.5 (2)	1.52	1.37	8.06	113.4	1.89	2.8	8.4	9.0	6.0	4.0
	Half Core: Half Dist. Layer: Half Core: Half Dist. Layer	2-256 gsm Cores: 60% SAP 40% NB416 + 2-50 gsm DLs													

Table 13

Internal code	Experimental Code	Sample Description	PVW Press.	Fluid Absorbed over Control g	Fluid over Core normalized by Distrib. Matl. Wt. g/g	Fluid Retained in Distrib. Matl. g	60 min. Transfer Rate to Core g/min	60 min. Transfer Rate to Core g/min/g-DL	60 min. Flux thru Distrib. Material g/min/cm ²	Core Absorption Work Integral g-cm	Total Absorption Work Integral g-cm	Core Absorpt. Work Ratio
	Layering Configuration											
1	Full Core: Full Dist. Layer: Half Core	1-512 gsm Core: 60% SAP 40% NB416 + 1-90 gsm DL	0.2		0.00	4.31	1.56	1.33	2.2	435	463	
2	Half Core: Full Dist. Layer: Half Core	2-256 gsm Cores: 60% SAP 40% NB416 + 1-90 gsm DL	0.2	-4.1	-3.3	5.51	1.48	1.20	2.2	397	439	0.91
3	Half Dist. Layer: Full Core: Half Dist. Layer	2-50 gsm DLs + 1-512 gsm Core: 60% SAP 40% NB416	0.2	9.1	5.9	4.97	1.71	1.11	2.0	511	544	1.17
4	Half Core: Half Dist. Layer: Half Core: Half Dist. Layer	2-256 gsm Cores: 60% SAP 40% NB416 + 2-50 gsm DLs	0.2	15.2	10.0	5.78	1.79	1.18	2.0	513	559	1.18

FIGURE 18

Table 14

Core = M&J airfield web, 60% BASF SAF + 40% NB416 pulp																												
Experimental Code	Sample Description	P/W Press.	Distib. Material Code	Distib. Material BW	Distib. Material OD wt.	Distib. Material caliper	Sample Total OD wt.	Fluid Absorbed in 60 min.	60 min. Absorption Rate	Absorption Time (min.) to Mass:				Fluid Absorbed over Core only	Fluid over Core normalized by Distib. Mat. Vt.	Fluid Retained in Distib. Mat.	60 min. Transfer Rate to Core	60 min. Transfer Rate to Core	60 min. Flux thru Distib. Material	Core Absorption Integral	Total Absorption Integral	Core Work Ratio						
				g	g	mm	g	g	g/min	25 g.	50 g.	75 g.	100 g.	125 g.	g	g/DL	g	g/min	g/min	g/min	g-cm	g-cm						
Set 1 = comparison of different DLs + fixed core in fluid through the DL only																												
1) BASF Core + 1085-2 (UDL only in fluid reservoir)	Core + dispo-made 1085-2 UDL	0.2	1085-XNP 2	89	1.22	0.79	8.42	110.8	13.2	0.22	2.85	7.58	16.9	38.5	-	8.5	6.6	4.4	2.60	-	-	4.58	1.77	1.46	3.62	586	620	
2) BASF Core + 1093-1 (UDL only in fluid reservoir)	Core + wellfield 1093-1 UDL	0.2	1093-XNP 1	88	1.20	1.10	8.47	112.2	13.2	0.22	2.04	5.08	12.0	33.9	-	12.3	9.9	6.3	2.95	-	-	4.95	1.79	1.48	2.63	586	621	
3) BASF Core + 1093-2A (UDL only in fluid reservoir)	Core + wellfield 1093-2A UDL	0.2	1093-XNP 2A	55	0.74	0.69	8.18	115.8	14.2	0.24	2.87	6.29	12.9	32.2	-	9.4	7.9	5.8	3.10	-	-	2.53	1.89	2.54	4.30	560	578	
4) BASF Core + 1093-4B (UDL only in fluid reservoir)	Core + wellfield 1093-4B UDL	0.2	1093-XNP 4B	53	0.73	0.52	8.36	120.8	14.5	0.24	3.19	7.03	13.5	29.1	-	7.8	7.1	5.5	3.44	-	-	2.84	1.97	2.71	6.02	608	628	
5) BASF Core + 1093-4B-4Z (UDL only in fluid reservoir)	Core + wellfield 1093-4B-4Z softened UDL	0.2	1093-XNP 4B-4Z	55	0.75	0.44	8.27	99.0	12.0	0.20	5.16	13.5	28.2	-	-	4.8	3.7	2.7	-	-	-	2.62	1.61	2.15	5.84	452	470	
6) UDL Only - 1093-4B-1-4Z (UDL in fluid reservoir)	UDL only: 1093-4B-1-4Z softened 1093-4B-4Z	0.2	1093-XNP 4B-4Z	54	0.73	0.44	0.73	5.0	6.8	0.67	0.92	-	-	-	-	-	-	-	-	-	-	3.80	-	-	2.37	-	31	
Set 2 = comparison of a standard airfield core to a core + DL, both in the fluid reservoir																												
7) BASF Core Only (Control) (Core only in fluid reservoir)	Core only: BASF SAF (UDL in fluid reservoir)	UDL	1085-XNP				16.4	18.6	15.7	0.24	0.43	1.02	5.03	19.1	-	5.8	5.0	3.0	2.03	-	-	-	-	-	-	768	810	1.03
8) BASF Core + 1093-2A (UDL in fluid reservoir)	Core + wellfield, 1093-2A UDL, both in reservoir	0.2	1093-XNP 2A	54	0.74	0.66	8.80	133.8	15.2	0.25	0.33	0.78	2.04	5.49	16.5	76.9	64.1	36.9	18.2	7.58	17.4	23.66	3.52	0.23	0.44	782	810	1.03

FIGURE 19

