PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : A61F 2/06

A1

(11) International Publication Number: WO 00/51524

(43) International Publication Date: 8 September 2000 (08.09.00)

(21) International Application Number: PCT/US00/02404

(22) International Filing Date: 31 January 2000 (31.01.00)

(30) Priority Data:

60/123,111	5 March 1999 (05.03.99)	US
09/420,038	18 October 1999 (18.10.99)	US

(71) Applicant: DATASCOPE INVESTMENT CORP. [US/US]; 14 Philips Parkway, Montvale, NJ 07645 (US).

(72) Inventor: DU, George, W.; 4142 La Salle Drive, Palm Harbor, FL 34685 (US).

(74) Agent: RONAI, Abraham; Datascope Corp., 14 Philips Parkway, Montvale, NJ 07645 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

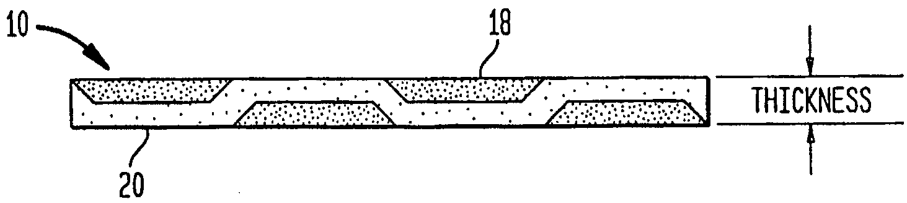
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ULTRA–THIN LOW POROSITY ENDOVASCULAR GRAFT

(57) Abstract

An ultra–thin endovascular graft having a low rate of water permeation. The woven graft fabric (10) comprises untwisted non–slashed multifilament warp yarns (18) and fill yarns (20) capable of flattering upon weaving.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

TITLE: ULTRA-THIN LOW POROSITY ENDOVASCULAR GRAFT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a woven fabric for an endovascular application. More particularly, the invention relates to an ultra-thin low porosity woven fabric for use in endovascular grafts.

2. Description of the Prior Art

An abdominal aortic aneurysm (AAA) is a sac caused by an abnormal dilatation of the wall of the aorta as it passes through the abdomen. The aorta is the main artery of the body, supplying blood to all organs and parts of the body except the lungs. It arises from the left ventricle of the heart, passes upward, bends over and passes down through the thorax and through the abdomen, and finally divides into the iliac arteries which supply blood to the pelvis and lower extremities.

The AAA ordinarily occurs in the portion of the aorta below the kidneys. When left untreated, the aneurysm will eventually cause the sac to rupture with ensuing fatal hemorrhaging in a very short time. The repair of abdominal aortic aneurysms has typically required major abdominal surgery in which the diseased and aneurysmal segment of the aorta is bridged with a prosthetic device, such as a synthetic graft.

As with all major surgeries, there are many disadvantages to the above mentioned surgical technique, the foremost of which is the high mortality and morbidity rate associated with surgical intervention of this magnitude. Other disadvantages of conventional surgical repair include the extensive recovery period associated with such surgery; difficulties in suturing the graft to the aorta; the unsuitability of the surgery for many patients, particularly older patients exhibiting comorbid conditions; and the problems associated with performing the surgical procedure on an emergency basis after the aneurysm has already ruptured.

In view of the above mentioned disadvantages of conventional surgical repair techniques, techniques have been developed for repairing AAAs by intraluminally delivering an aortic graft to the aneurysm site through the use of a catheter based delivery system, and securing the graft within the aorta using an expandable stent. Since the first documented clinical application of this technique was reported by Parodi et al. in the Annals of Vascular Surgery, Volume 5, pages 491-499 (1991), the technique has gained more widespread recognition and is being used more commonly.

Use of the stent/graft deployment catheter eliminates the problem of suturing the graft to the aorta associated with surgical repair techniques. However, use of the catheter still requires a cut-down surgery to locate and expose the blood vessel, and thus, the patient recovery time is still quite long. Therefore, the need exists for a stent/graft deployment catheter and a stent/graft which are small enough to be inserted percutaneously into the blood vessel of the patient. The term stent/graft, as herein used, refers to a stent and graft assembly, a stent alone, or a graft alone. A percutaneous procedure would avoid the surgery necessary to locate the blood vessel and thereby decrease patient recovery time significantly. The presence of such a catheter and stent/graft on the market may finally allow for the full transition from the currently used surgical cut-down method of stent/graft insertion to the much preferred percutaneous insertion method. As of yet, such a catheter has not appeared on the market because of the difficulty inherent in designing a catheter and stent/graft small enough to be inserted percutaneously. The present invention discloses a graft material which is greater than 50% thinner than prior art graft materials, and thus, given the existence of an appropriately sized stent/graft deployment catheter, capable of percutaneous insertion.

Various synthetic vascular grafts have been proposed to replace, bypass or reinforce, diseased or damaged sections of a vein or artery. Commonly, tubular grafts have been formed from knitted or woven continuous filament polyester fiber (Dacron Registered TM) and from expanded polytetrafluoroethylene (PTFE).

The performance of a vascular graft is influenced by a variety of characteristics such as strength, permeability, tissue ingrowth, and ease of handling. A graft should be sufficiently strong: (a)to prevent the sidewalls from bursting when blood is flowing through the device even at high blood pressures; and (b) to maintain the patency of the vessel lumen. Furthermore, a graft sidewall must be sufficiently impervious to blood to prevent hemorrhaging as blood flows through the graft.

Expanded grafts are inherently leak resistant. Woven and knitted grafts, on the other hand, may require sealing of the openings between adjacent interlacings to prevent blood leakage. Sealing of said openings may be accomplished through a pre-clotting procedure. Pre-clotting involves immersing a woven or knitted graft in the patient's blood and then allowing the graft to dry until the interstices in the graft fabric become filled with the clotted blood. Another common technique for sealing the above mentioned openings is to coat the graft with an impervious material such as albumin, collagen or gelatin. Tissue ingrowth through the interstices of the graft is believed to nourish and organize a thin neointima lining on the inner surface of a graft, preventing clotting of blood within the lumen of the graft which could occlude the graft. A velour surface may be provided on the outer surface of a woven or a knitted graft to encourage tissue infiltration. The pore size of a graft also influences tissue ingrowth. Although larger openings facilitate tissue penetration, pre-clotting or coating of the graft may be adversely affected as pore size increases.

Ease of handling is another important feature of an vascular graft. A flexible and conformable graft facilitates placement of the prosthesis by the surgeon. Increased elasticity, particularly of woven grafts has been achieved by crimping the graft. Crimping also improves resistance to kinking when the graft is bent or twisted. Woven and knitted grafts generally have been formed from continuous filament polyester yarns which typically are textured prior to fabrication to impart bulk and stretch to the vascular graft fabric. A technique known as false twist texturizing has been employed which involves the steps of twisting, heat setting and then untwisting the continuous multifilament yarns, providing substantially parallel, wavy filaments.

Graft selection for a particular application has therefore involved trade-offs and compromises between one or more of the above properties. Expanded PTFE grafts provide strong structures which are non-porous and impervious to blood leakage. The absence of pores, however, precludes tissue ingrowth. Expanded PTFE grafts also may be stiff and nonconforming which detrimentally affects handleability. Knitted grafts have attractive tissue ingrowth and handleability features. The porous structure of knitted grafts, however, requires that the graft be pre-clotted or coated to prevent hemorrhaging. Woven grafts are less porous than knitted grafts and may not require pre-clotting or coating. The tightly compacted weave structure, however, may provide a stiff prosthetic which is not as conformable or as easily handled as is a knitted graft.

The major constraints involved in designing a percutaneously insertable woven endovascular graft, the focus of the present invention, are thickness and porosity/water permeability. It is convenient to refer to the rate of water permeation through the graft fabric as a standard measure. The rate of water permeation is defined here as the amount (ml/minute) of water permeating through one square centimeter of the surface of a graft under 120 mm Hg of pressure. To prevent blood leakage into a graft the rate of water permeation should be below 500 ml/min/cm^2. Conventional woven vascular grafts require a woven fabric thickness of thicker than 0.25 mm in order to achieve a rate of water permeation of lower than 500 ml/min/cm^2. Although this limitation is acceptable for bypass vascular grafts where the bulkiness of the fabric is not critical, it imposes a significant problem with respect to using woven fabrics for endovascular stent/grafts. In order to load a stent/graft device onto a percutaneous delivery system, the woven graft fabric used must be in the order of thinner than 0.1 mm, which is on average 3 to 6 times thinner than that of conventional bypass vascular grafts. Currently, the weaving technology for making such a thin fabric (<0.1 mm) with low porosity (water permeability lower than 500 ml/min/cm^2) is not available.

The present invention accomplishes a dramatic reduction in graft woven fabric thickness through the use of non-slashed untwisted yarn. For practical purposes most textiles are generally woven from twisted yarns. Grafts are generally manufactured with at least the warp yarn twisted. Twisting of the yarns acts to bond all the filaments, making up the yarn, together. Bonding of the filaments is important because it assures that if a portion of one filament breaks along its length it does not simply fall out or hang loose from the woven fabric. It is important for most fabrics that surface abrasion, whether during the weaving process itself or during actual use of the fabric, does not cause the woven fabric to easily fall apart.

Attempts have been made to increase the flexibility of grafts, while still maintaining a rate of water permeation of less then 500 ml/min/cm^2, by forming the prosthesis from very thin fibers having less than one denier per filament ("micro-denier"). Use of these thin fibers results in an overall thinner graft. Representative are U.S. Pat. Nos. 4,695,280 and 4,743,250 which disclose artificial vascular grafts which have been formed from a combination of micro-denier filament yarns and larger yarns. Use of microfilament yarns may achieve graft thickness of less than 0.1 mm, however the water permeability of such grafts is significantly greater than 500 ml/min/cm^2, and the grafts may chemically degrade over a long period of time. Presently, there is no reliable clinical data available to support the use of filaments with linear density of 1.0 denier or less. All commercially available textile vascular grafts are made of polyester yarns having a minimum filament linear density of approximately 1.5 denier, such as 40/27 Dacron (40/27 is shorthand for a 40 denier yarn having 27 filaments of 1.48 denier each).

While the micro-filament artificial vascular grafts may be suitable for the particular purpose employed, or for general use, they would not be as suitable for the purposes of the present invention as disclosed hereafter.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to produce an ultra-thin endovascular graft appropriate for percutaneous insertion.

It is another object of the invention to produce a graft fabric having a low porosity, and thus, a low rate of water permeation.

The invention is an ultra-thin endovascular graft having a low rate of water permeation. The woven graft fabric comprises untwisted non-slashed multifilament yarns capable of flattening upon weaving.

To the accomplishment of the above and related objects the invention may be embodied in the form illustrated in the accompanying drawings. Attention is called to the fact, however, that the drawings are illustrative only. Variations are contemplated as being part of the invention, limited only by the scope of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like elements are depicted by like reference numerals. The drawings are briefly described as follows.

FIG 1 is a plan view of a prior art graft fabric woven with twisted yarns.

FIG 1A is a cross section view of the fabric illustrated in FIG 1 taken along lines 1A-1A.

FIG 2 is a plan view of an improved graft fabric woven with non-twisted yarns.

FIG 2A is a cross sectional view of the fabric illustrated in FIG 2 taken along lines 2A-2A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In conventional woven graft design, textile yarns with a substantial level of twist, at least in the warp direction, are used to construct the graft fabric. Due to the existence of twist, the cross sectional shape of woven yarns is either round or ellipse, depending on the level of twist and the compacting motion the yarns are subjected to during and after weaving.

FIG 1 illustrates a plan view of a prior art woven graft fabric, designated generally 10, comprising a plurality of twisted warp yarns 12 and twisted fill yarns 14 woven together in a conventional 1/1 plain weave.

FIG 1A illustrates a cross section of the woven fabric 10 taken along lines 1A-1A. It can be seen in FIG 1A that the thickness of the woven fabric 10, labeled Thickness, equals approximately the sum of both the twisted warp yarn 12 and the twisted fill yarn 14 thicknesses. The presence of twist on the yarns makes them generally rigid and incompressible. Therefore, upon weaving, the twisted incompressible yarns maintain their round-ellipse cross sectional shape rather than flattening out. The presence of twist on yarns 12 and 14, and the resultant round-ellipse cross sectional shape of yarns 12 and 14, aside from preventing flattening, also results in the introduction of unnecessary large interstices 16 between the yarns 12 and 14, as shown in Figure 1.

Based on the Kozeny-Carmen flow model, water permeability has the following expression:

$$WP \propto \frac{d^2}{\sqrt{t}} \cdot \frac{\varepsilon^3}{(1-\varepsilon)^2} \qquad (1)$$

Equation (1) indicates that the effect of both fabric porosity (ε) and filament diameter (d) on water permeability (WP) is significantly greater than that of fabric thickness (t). Accordingly, the large yarn interstices 16, which are present due to the twist on the yarns 12 and 14, significantly raises the water permeability of the graft fabric 10 by increasing the level of fabric porosity.

In order to assure that the water permeability level remains below 500 ml/min/cm^2, grafts are usually made with a thickness greater than 0.1 mm. In clinical practice, surgical grafts thicker than 0.1 mm are not problematic and in most cases are necessary for required strength. However, grafts thicker than 0.1 mm are considered too bulky for endovascular applications. Use of microfilament yarns in a twisted format, such as 30/30 (30 denier with 30 filaments of 1.0 denier each) polyester yarns, may achieve graft thickness of less than 0.1 mm. However, the water permeability of such a graft is significantly greater than 500 ml/min/cm^2, and the graft may chemically degrade over a long period of time. Presently, there is no reliable clinical data available to support the use of filaments with linear density of 1.0 denier or less. All commercially available textile vascular grafts are made of polyester yarns having a minimum filament linear density of approximately 1.5 denier, such as 40/27 Dacron.

As discussed above, the best solution to the problem of reducing the fabric thickness (*t*) while maintaining (or even lowering) the level of water permeability (*WP*) and the linear density of polyester filaments is to lower the fabric porosity (e). The most efficient method in eliminating the void content of the graft fabric 10 is to reduce the dimension of the yarn interstices 16, as explained above. This invention provides a unique method to make woven vascular grafts thinner (<= 0.1 mm) and less porous (water permeability lower than 500 ml/min/cm^2) than current commercially available vascular grafts.

FIG 2 illustrates a plan view of an improved ultra-thin graft fabric 10. The graft fabric 10 comprises a plurality of non-twisted warp yarns 18 and a plurality of non-twisted fill yarns 20 woven together in a conventional 1/1 plain weave. Both the warp yarns 18 and the fill yarns 20 used to weave the graft fabric 10 are multifilament polymeric yarns, textured or flat, non-twisted or only slightly twisted, with a surface twist angle of less than approximately 5 degrees, but preferably non-twisted. The linear densities for the warp yarns 18 and fill yarns 20 may be different or identical, depending on the weavability and design of woven construction.

The number of filaments within the yarns 18 and 20 should be sufficient, preferably more than 20 filaments per yarn, for the yarns 18 and 20 to change their cross-sectional shapes, i.e. flatten, during and after weaving. The yarns 18 and 20 are capable of changing their shape during and after weaving because they are non-twisted and non-slashed, i.e. have not gone through the slashing process. The filaments of non-slashed yarn are not bound together by an adhesive, and therefore, can change shape during and after weaving. The weave pattern can be plain, twill, satin or sateen, but preferably 1/1 plain weave because it has the highest degree of interlacing. The surface of a graft, made from the graft fabric 10, can be smooth or a single or double velour, but preferably smooth because the presently disclosed graft fabric 10 is intended for an endovascular application. Constructing and arranging the graft fabric 10 into a tubular configuration, having a lumen for conveying blood therethrough, is well known in the art. In order to achieve optimal fabrication results sufficient yarn tensions should be applied during the weaving process, followed by compacting and heat-setting the graft fabric 10 on appropriate mandrels at a raised temperature above the glass transition temperature and below the melting temperature. Note that use of non-twisted yarn in only one of the directions in the graft fabric 10, warp or fill, is also anticipated.

The non-existence of yarn twists (or the presence of a small amount of twist) and the large number of filaments allows the yarns 18 and 20 to form desirable cross-sections close to an idealized equilateral trapezoidal shape, which practically eliminates the interstices 16 between the yarns 18 and 20, as illustrated in FIG 2. As depicted in FIG 2A, the flattened yarn cross-section, which has an idealized Equilateral Trapezoidal shape, not only eliminates the yarn interstices 16, but also results in a significantly thinner woven structure. The following example provides a strong evidence for all the claims detailed above. It is to be understood, however, that the examples are included for illustrative purposes only and are not intended to limit the scope of the invention as set forth in the accompanying claims. Design I uses a conventional approach in which twisted warp and twisted fill yarns are used. The objective of Design II is to reduce the graft thickness to half, while maintaining or even lowering the water permeability by using non-twisted yarns as suggested by this invention.

	Design I (Conventional)	Design II (This Invention)
Warp/Filling Yarns	40 denier/27 fila.	40 denier/27 fila.
		Dacron 56
	Dacron 56	
Yarn Twist	7.5 tpi	0.0 tpi (non-twisted)
Warp Density	316 ends/inch	128 ends/inch
Filling Density	88 picks/inch	128 picks/inch
Area Density	404 yarns/square inch	256 yarns/square inch
Weave Pattern	1/1 plain	1/1 plain
Graft Diameter	24 mm	24 mm
Graft Thickness (measured)	0.145 mm	0.070 mm
Water Permeability (measured)	523 ml/min/cm^2	319 ml/min/cm^2

As shown in the above Table, despite the fact that the Design I graft has an area density (404 yarns/square inch) approximately 60% higher than that of the Design II graft (256 yarns/square inch), and a thickness (0.145 mm) of over 200% the thickness of the Design II graft (0.070 mm), its water permeability is measured to be above 60% higher. This example demonstrates that by using the approach based on this invention, it is possible to make woven endovascular grafts much thinner than 0.1 mm with a water permeability lower than 500 ml/min/cm^2.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

CLAIMS

What is claimed is:

1.A woven graft comprising substantially non-twisted yarns in both the warp and fill directions.

2.The graft as claimed in claim 1 wherein the graft is a woven vascular graft.

3.The woven vascular graft as claimed in claim 2 wherein the non-twisted yarns are polymeric, non-slashed, and have at least ten filaments per yarn.

4.A woven graft comprising twisted fill yarns and substantially non-twisted warp yarns.

5.The graft as claimed in claim 4 wherein the graft is a woven vascular graft.

6.The woven vascular graft as claimed in claim 5 wherein the non-twisted warp yarns are polymeric, non-slashed, and have at least ten filaments per yarn.

7.A woven graft comprising warp yarns and fill yarns each having a surface twist angle of less than about 5 degrees.

8.The graft as claimed in claim 7 wherein the graft is a woven vascular graft.

9.The woven vascular graft as claimed in claim 7 wherein the warp yarns and the fill yarns are polymeric, non-slashed, and have at least ten filaments per yarn.

10.A woven graft comprising warp yarns and fill yarns, said warp yarns having a surface twist angle of less than about 5 degrees.

11.The graft as claimed in claim 10 wherein the graft is a woven vascular graft.

12.The woven vascular graft as claimed in claim 11 wherein the warp yarns are polymeric, non-slashed, and have at least ten filaments per yarn.

13. A woven graft comprising at least two non-twisted interwoven yarns.

14. The graft as claimed in claim 13 wherein the graft is a woven vascular graft.

15. The graft as claimed in claim 13 wherein at least one of the yarns is polymeric, non-slashed, and has at least ten filaments per yarn.

16. The graft as claimed in claims 1, 4, 7, 10, 13, and 14 wherein the graft has a thickness of less than approximately 0.14 mm.

17. The graft as claimed in claim 1, 4, 7, 10, 13, and 14 wherein the graft has a thickness of less than approximately 0.070 mm.

18. The graft as claimed in claim 1, 4, 7, 10, 13, and 14 wherein the warp and fill yarns each being 40 denier and having 27 filaments.

19. The graft as claimed in claim 1, 4, 7, 10, 13, and 14 having a water permeability of less than about 523 $ml/min/cm^2$.

FIG. 1
(PRIOR ART)

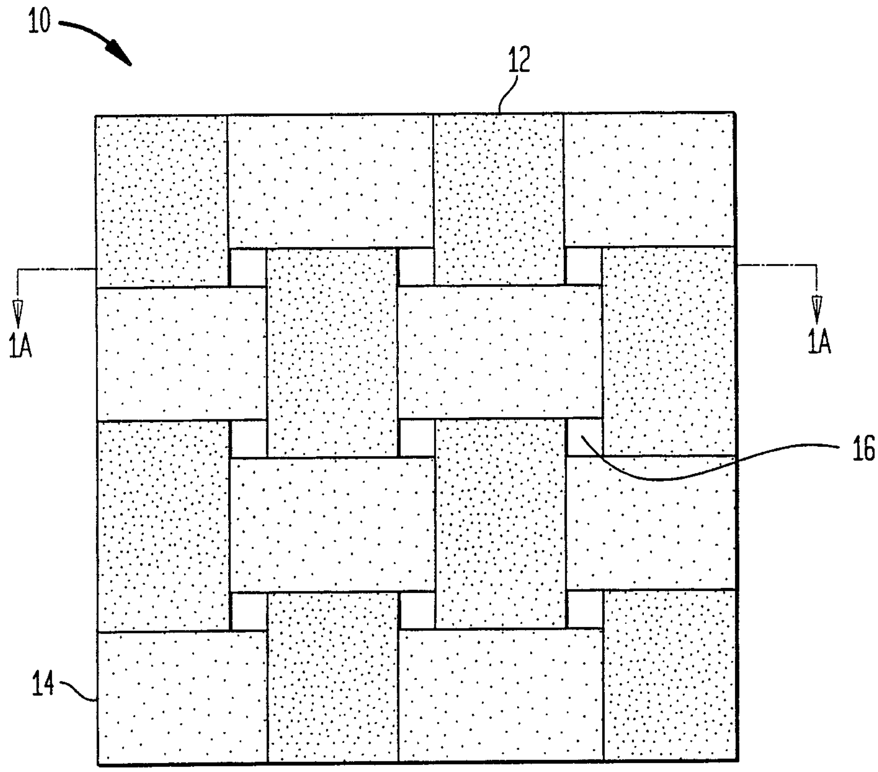


FIG. 1A
(PRIOR ART)

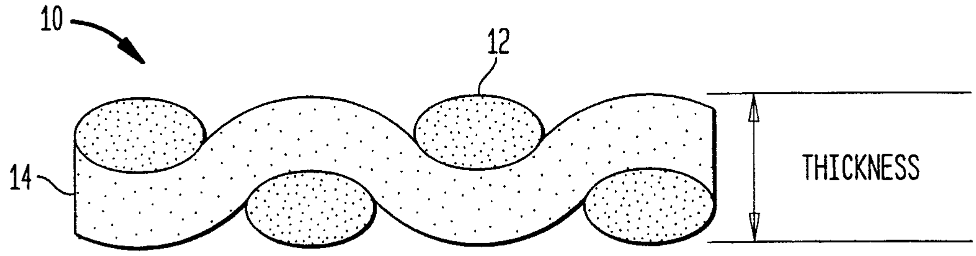


FIG. 2

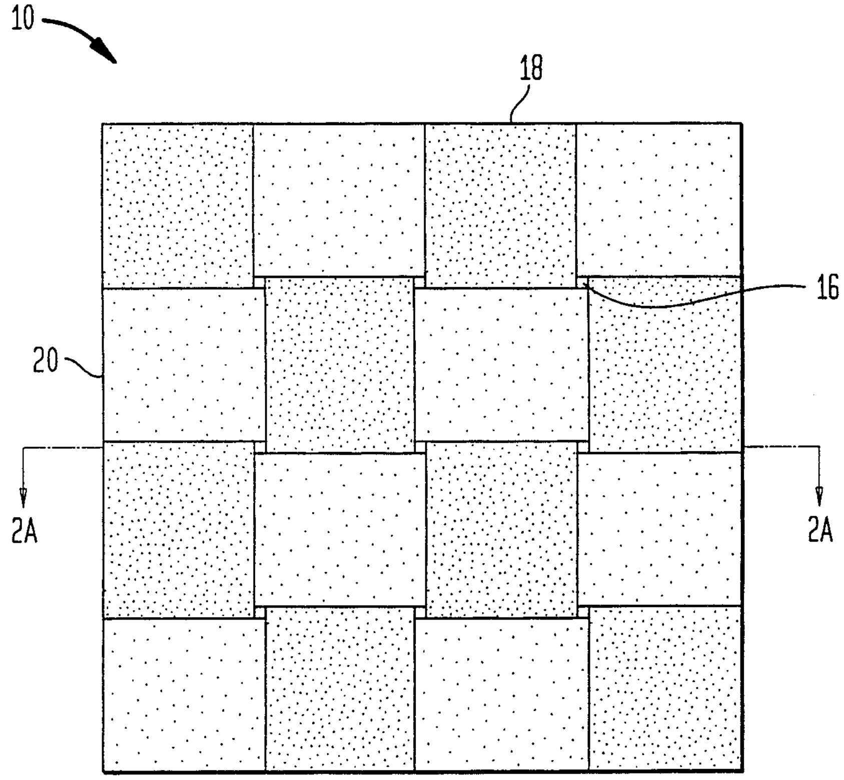
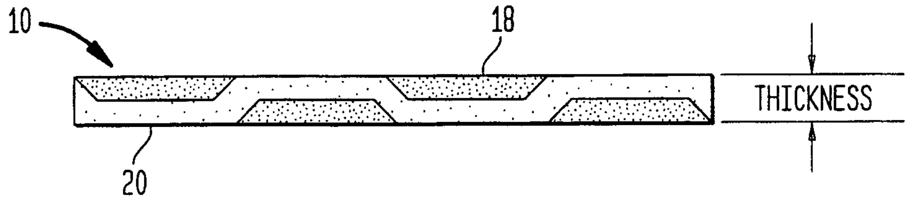


FIG. 2A



INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/02404

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61F2/06

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 191 218 A (CLARK RICHARD E ET AL) 4 March 1980 (1980-03-04) claims 8,10; figures 9,10 column 1, line 17 - line 23 column 3, line 16 - line 32 column 7, line 4 - line 44	1-3,7-17
A		4-6,18

X	GB 1 173 811 A (WILLIAM JOHN LIEBIG) 10 December 1969 (1969-12-10) claims 1,6; figures 1,4 page 5, line 35 - line 94	1-3, 7-15,19
A		4-6,18

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

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

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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2000	07/07/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Stach, R

1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/02404

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 464 755 A (NISSHO KK) 8 January 1992 (1992-01-08) figure 7 page 6, line 48 - line 53 page 11, line 31 - line 42 ---	4-6
A	DE 196 13 317 A (SGRO JEAN CLAUDE) 10 October 1996 (1996-10-10) figure 2 page 3, line 42 - line 50 -----	4

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/02404

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4191218 A	04-03-1980	US 4340091 A	20-07-1982
		US 4192020 A	11-03-1980
GB 1173811 A	10-12-1969	NONE	
EP 0464755 A	08-01-1992	JP 2619972 B	11-06-1997
		JP 4061863 A	27-02-1992
		JP 4073057 A	09-03-1992
		DE 69109374 D	08-06-1995
		DE 69109374 T	25-01-1996
		US 5236447 A	17-08-1993
DE 19613317 A	10-10-1996	FR 2732582 A	11-10-1996
		ES 1033775 U	16-10-1996
		IT MI960253 U	03-10-1997