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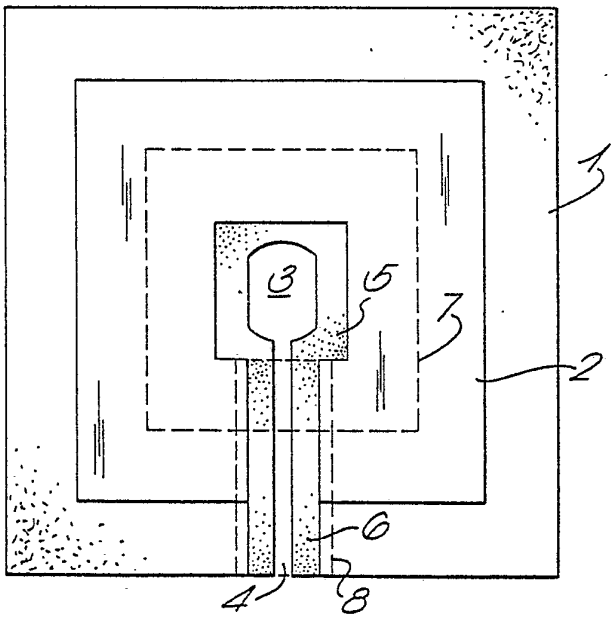
(57) Abstract

Disposable apparel, especially disposable surgical apparel comprises, as a protective barrier layer, a nonwoven web (1) including or consisting of fibrillated electret fibers, e.g. of polypropylene, the electret fibers in said web having a weight of not more than 75 g/m2, preferably not more than 50 g/m2, and said fibers having an average width or diameter of at least 10 microns. The apparel may include support means for the protective barrier layer such as two webs of nonwoven fabric (31) and (33) retaining the protective barrier layer (30) therebetween. A method of producing the apparel is described in which the protective barrier layer is provided by laying a web of fibrillated electret fibers by air-laying means.



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DISPOSABLE SURGICAL APPAREL AND METHOD OF PRODUCING IT

This invention relates to disposable apparel, especially disposable surgical apparel, and to a method of producing it.

Surgical apparel has been employed in surgery for some time to prevent pathological micro-organisms, such as bacteria, emanating from the wearer from contaminating the patient undergoing surgery, and also to protect the wearer from bacteria emanating from the patient. For example, bacteria may be exhaled by the wearer and/or by the patient. Further, the human body is constantly shedding flakes of dead skin; such flakes are often contaminated by bacteria.

Amongst the surgical apparel employed in surgery are surgical gowns, head-wear and scrub clothing such as scrub-suits, worn by the surgeon or operating-theatre staff, and surgical drapes placed on the patient. In the past, re-usable surgical apparel has been employed which requires laundering and sterilisation after each use, but more recently disposable, i.e. single-use, surgical apparel has come into use. Such surgical apparel relies on mechanical action, namely an arrangement of filaments or fibers of particular diameter defining areas of relatively small size, to trap bacteria and particles contaminated by bacteria.

The present invention provides an item of disposable apparel, especially disposable surgical apparel, comprising, as a protective barrier layer, a web comprising electret fibers, particularly fibrillated electret fibers, having an average diameter or width of at least 10 microns, the electret fibers in said web having a weight of not more than 75 g/m^2, preferably not more than 50 g/m^2.

Preferably the electret fibers are of polypropylene, but other plastics fibers, e.g. polytetrafluoroethylene fibers, which can be electrically charged and retain such charge, can be used. When fibrillated fibers are used, they may be electrically charged before or after fibrillation. The fibrillated fibers are substantially rectangular in section and may, for example, have a depth of about 10 microns

and an average width of about 40 microns, individual fibers having a width varying from at least 10 microns to about 100 microns. (1 micron = 1 x 10^{-6}m).

Electret fibers trap bacteria and particles by means of electrostatic attraction and constitute a highly efficient filter medium. They are described, for example, in the Paper entitled "Non-woven electret fibre: a new filtering medium of high efficiency" by J. van Turnhout et al appearing in Inst. Phys. Conf. Ser. No. 48 at Page 337, published by The Institute of Physics. Although this Paper suggests the industrial use of fibrillated electret filters, e.g. in industrial face masks, there has not been, to our knowledge, any suggestion of their use in items of disposable apparel. Indeed, by virtue of their weight, in excess of about 150 g/m^2, which, along with needle punching, is necessary to maintain their integrity, the commercially available electret filters are far too bulky, heavy and unconformable to be used in items of disposable apparel.

In one embodiment of the present invention the electret fibers may be present in the web along with other textile fibers. Suitable textile fibers include natural and/or man-made fibers e.g. cellulosic fibers such as viscose rayon fibers or cotton fibers. Synthetic fibers such as nylon, polyester or polypropylene fibers may be used. Preferably said textile fibers are heat-sealable to facilitate make-up of the disposable surgical apparel, e.g. sheath-core fibers having a polypropylene core and a polyethylene sheath. Such fibers can also be electrically charged to produce electret fibers.

In an alternative embodiment, the web may be constituted wholly of electret fibers. Whether the web consists of or includes electret fibers, it may be supported by one or more fabric webs. For example, it may be laminated to one or more plies of a nonwoven fabric comprising textile fibers as mentioned above, or may be supported by and retained between webs of nonwoven fabric. For example, a web consisting of electret fibers having a weight of not more than 75 g/m^2, preferably not more than 50 g/m^2, is laminated between two plies of nonwoven fabric each having a weight of not more

than 75 g/m^2, preferably not more than 50 g/m^2.

The web of electret fibers or electret precursor fibers may be stabilised by printing with a binder and/or by re-arrangement, entanglement, or "bundling" with fluid streams, e.g. in accordance with the process described in British Patents Nos. 816,673, 836,396 and 836,397. In the "bundling" process, it is preferred to use high pressure, e.g. about 110,326 kPa (16,000 lbs/sq. in.), low-diameter fluid streams so that the apertures produced in the web are of 25 microns diameter or less, i.e. within the size range of the gaps between the individual electret fibers.

Preferably the web constituting the protective barrier layer is air-laid, although it may be dry-laid, as by carding, if desired.

Although the use of fibrillated electret fibers is preferred, other electret fibers, e.g. melt-extruded electret fibers, may be used instead.

The present invention further provides a method of producing disposable apparel, especially disposable surgical apparel, including the steps of laying one or more webs comprising electret fibers or electret-precursor fibers, preferably fibrillated fibers, said fibers having, in the web or combined webs, a weight of not more than 75 g/m^2 and the fibers having an average diameter or width of at least 10 microns, and processing the web into an item of said disposable apparel. When electret-precursor fibers are used, they are electrically charged after formation of the web.

Preferably said web is laminated to at least one web of fabric, preferably nonwoven fabric, and the laminated webs are processed into the disposable apparel.

In one embodiment of the method of the present invention, a commercially available needle-punched web of fibrillated electret fibers may be used as a starting material. A web of fibrillated electret fibers produced in the manner described in British Patent No. 1,469,740 may be cut into lengths, air-laid, and needle-punched to provide the web of starting material. Such a web has a weight considerably in excess of 75 g/m^2, e.g. 150 g/m^2 or more.

A web having a weight of no more than 75 g/m^2, preferably no more than 50 g/m^2 may be reconstituted from the heavier-weight precursor web using the method and/or apparatus described in British Patent Specifications Nos. 1,375,584 and 1,375,585.

The web of desired weight may be laid onto a web of fabric, preferably nonwoven fabric, forming a support. Another support layer of fabric, preferably nonwoven fabric, may be laid onto the electret fiber web, and the laminate formed is processed into disposable apparel.

Instead of winding the fibrillated fibers directly onto a roller as in the aforementioned British Patent Specification No. 1,469,740, the fibrillated fibers leaving the fibrillator may, in another embodiment of the method of the present invention, be chopped into about 5 cm. lengths, and carded into a web in which the fibers extend longitudinally thereof. The carded web is doffed without coming into contact with metal, and may be laid onto a web of fabric, preferably nonwoven fabric, forming a support layer. If desired, one or more carded webs may be deposited from other carding engines onto the first carded web to produce a web of electret fibers of desired thickness and weight. For example, four carding engines may be employed each to produce a web weighing about 6 g/m^2 which, superimposed, produce an overall web weighing about 24 g/m^2. Another support layer of nonwoven fabric may be laid onto the carded web and the laminate formed is processed into an item of disposable apparel.

In yet another embodiment of the method of the present invention the web of fibrillated film is not chopped and carded, but is spread out immediately after leaving the fibrillator with the fibers extending substantially longitudinally of the web. The web is laid onto a web of nonwoven fabric forming a support layer for a laminate. Two or more such fibrillated webs may be superimposed to form an electret filter web of desired thickness and weight. Another support layer of nonwoven fabric is laid onto the fibrillated fiber web, and the laminate formed is processed into an item of disposable surgical apparel.

In this embodiment, the fibrillated electret fibers are continuous.

The binder, when used, may be applied to the unbonded web of fibrillated fibers by, for example, a rotogravure print roller. Reference is also made to Figure 5 of British Patent Specification No. 742,089 for suitable apparatus for carrying out the bonding step. The binder is preferably distributed uniformly throughout the web, i.e. continuously or in regularly spaced areas. A suitable binder is, for example, an acrylic binder as is well known in the art.

Disposable surgical apparel in accordance with the present invention may be made up partly or entirely from the web comprising electret fibers. For example, the disposable surgical apparel may be made up entirely from a web comprising electret fibers or may include one or more webs of other nonwoven fabric not containing electret fibers.

Some preferred embodiments in accordance with the present invention will now be described, by way of example, with reference to the accompanying diagrammatic Drawings in which:-

Figure 1 is a plan view of a disposable surgical drape;

Figure 2 is an elevation of a disposable back-opening surgical gown;

Figure 3 is a plan view of a disposable operating-theatre cap;

Figure 4 is an elevation of the cap of Figure 3;

Figure 5 is an elevation of a disposable tunic top;

Figure 6 is an elevation of disposable scrub trousers;

Figure 7 is an elevation of a disposable nurse's dress;

Figure 8 is a flow diagram of one method of producing the apparel; and

Figure 9 is a side elevation of apparatus for producing a three-ply laminar web used in the method of Figure 8.

Referring to Figures 1 to 7 of the Drawings, the items of disposable surgical apparel shown therein are made up of individual pieces or panels cut from a web comprising

electret fibers, the electret fibers in said web having a weight of not more than 75 g/m^2, preferably not more than 50 g/m^2.

Such a web acts as a protective barrier layer to pathological micro-organisms such as bacteria between the patient and/or operating theatre staff wearing the apparel and the environment.

The pieces or panels may be joined together by stitching, but when the web contains heat-sealable fibers, the pieces may be heat-welded together. Other methods such as adhesive-bonding may also be used.

Preferably the electret fibers are fibrillated polypropylene fibers. These fibers are substantially rectangular in section and have an average width of at least 10 microns. Preferably they have a depth of more than 10 microns and an average width of about 40 microns, individual fibers having a width varying from at least 10 microns to about 100 microns.

The web may include or consist of electret fibers. In the former case, the web may be an air-laid or carded web of electret fibers and textile fibers, said electret fibers constituting from 5 to 50% by weight of the web which weighs no more than 150 g/m^2. Suitable textile fibers are mentioned hereinabove. Such a web may be stabilised by adhesive bonding and/or by rearrangement, entangling or "bundling" with fluid streams. Such rearrangement, entangling or "bundling" is operated under conditions to produce apertures in the non-woven fabric of 25 microns diameter or less, e.g. including high-pressure, e.g. about 110,316 kPa (16,000 lbs/in.^{2}), low-diameter fluid streams.

The web may consist of electret fibers, the weight thereof being no more than about 75 g/m^2, preferably no more than 50 g/m^2. In this case the web of electret fibers is unbonded and stabilised by laminating it between two plies of nonwoven fabric each weighing no more than 75 g/m^2, preferably no more than 50 g/m^2. The plies may each be a carded nonwoven fabric bonded with a binder such as an acrylic binder, and may also be rearranged, entangled

or "bundled".

The disposable surgical drape shown in Figure 1 comprises a square web 1 comprising electret fibers. To the upper side of this web 1 is secured a smaller square panel 2 of thin, liquid-impermeable material e.g. a plastics film or plastics-coated nonwoven fabric. Both 1 and 2 are fenestrated at 3 as shown, a slot 4 extending from the fenestration 3 to a side edge of the web 1.

Coated on the marginal portions 5, 6 of the material surrounding fenestration 3 and slot 4 respectively is an adhesive for securing the drape to the patient's body. Prior to use, such adhesive areas are covered with silicone-coated release paper liners 7 and 8 shown in dotted outline.

The body of each item of disposable surgical apparel shown in Figures 2 to 7 is made up from pieces of a web comprising electret fibers.

Disposable apparel in accordance with the present invention may also be worn as protective clothing in ultra-clean areas, e.g. in the electronics and pharmaceutical industries.

One method of producing a laminar web from which the disposable surgical apparel of Figures 1 to 7 may be produced will now be described with reference to Figure 8.

A web 22 of plastics film, preferably polypropylene film, but alternatively of tetrafluoroethylene or other suitable plastics material, is extruded from extruder 23, advanced to stretching apparatus 24 in which the film is stretched uniaxially in the machine direction, advanced to corona charger 25 where the web is charged on both surfaces, and advanced to fibrillator 26 which splits the web into a web 27 of unbonded fibrillated interconnected electret fibers. The fibrillator 26 is operated in such a way that the fibrillated fibers have an average width of at least 10 microns, and extend substantially longitudinally of the web.

For further details of this sequence of steps and the apparatus employed, reference is made to British Patent Specification No. 1,469,740, the contents of which are

incorporated herein by reference.

Fibrillated film web 27 is then processed, as by cutting into lengths and air-laying followed by needle-punching in unit 27a, into a randomly-oriented bonded fibrous web 28 having a weight in the range of about 150 g/m^2 to about 250 g/m^2, which is wound up into a roll 28a.

The web 28 is far too bulky, heavy, and unconformable to be used as a protective barrier layer in disposable surgical apparel. Accordingly it is fed from roll 28a to a dual-rotor machine 29 described hereinafter with reference to Figure 9. In the dual-rotor machine 29, web 28 is reconstituted by air-laying into a web 30 of unbonded fibrillated interconnected electret fibers having a weight of no more than 75 g/m^2, preferably no more than 50 g/m^2. A web of such a weight, hereinafter referred to as a barrier web, is conformable, pliable, and comfortable to wear because of its low weight and very low air resistance.

The barrier web 30 is laid, in dual rotor machine 29, onto a support or carrier web 31 of nonwoven fabric e.g. "MASSLINN" nonwoven fabric weighing about 13 to 35 g/m^2, e.g. 18 to 24 g/m^2, advanced from a roll 32 thereof. Immediately after leaving machine 29, a similar web 33 of nonwoven fabric advanced from roll 34 thereof is laid upon the two-ply web comprising barrier web 30 supported by web 31 to produce a three-ply laminar web 35.

The web 35 may then be passed between calendering rolls 36 heated to a temperature of about 95°C to assist in compacting and bonding the web 35. Other compressing and heating means may be employed if desired.

The laminar web 35, after leaving calendering rolls 36, is then processed into disposable surgical apparel in unit 37. The web 35 may be processed into the apparel by cutting the web transversely into individual pieces or panels, and joining the pieces or panels together as above described.

The dual rotor machine 29 is shown in more detail in Figure 9, and is constructed and arranged to operate as described with reference to Figures 13 to 19 of British Patent Specification No. 1,375,584, the contents of which

are incorporated herein by reference. The machine comprises two saw-tooth wire wound lickerins 38 and 39, associated feed rollers 40 and 41, adjustable baffle 42, nose bars 43 and 44, and casting chamber 45 defined between doctor blades 46 and 47. An endless mesh screen conveyor 48 directed over pulleys 49 and driven by drive means (not shown) in a clockwise direction slides over a housing 50 containing an aperture 51 through which air is sucked into a conduit 52 leading to a suction fan (not shown).

In the method described above with reference to Figure 8, only the right-hand side of the machine is operated, i.e. only lickerin 39 is rotated, at high speed. The web 28 is fed in over feed roller 41 onto lickerin 39 which breaks up the web 28 to release the fibrillated fibers. After passing nose bar 44 the fibers enter casting chamber 45 through which high velocity air is drawn by the suction fan. The air stream strips fibers from lickerin 39 and are carried by the air stream past doctor blade 47 and deposited on web 31, advanced from roll 32 and itself supported on screen conveyor 48, to form barrier web 30. From screen conveyor 48, webs 30 and 31 are doffed onto a takeaway endless belt conveyor 53 driven in a clockwise direction. Web 33, advanced from roll 34, is laid upon the two-ply web immediately after it leaves machine 29 to provide three-ply web 35. Web 35 may be forwarded to calendering rolls 36 by conveyor 53.

The weight per unit area of the web 35 can be varied by varying the speed of the feed roller 41 of the dual rotor machine 29 in relation to the speed of the conveyor 48.

Alternatively, both sides of the dual rotor machine may be operated to produce, for example, a two-ply web.

Example

Disposable surgical apparel was produced using the apparatus described above, and webs of the following nonwoven fabrics. As web 28, a 150 g/m^2 web of needle-punched fibrillated polypropylene electret fibers obtained

commercially from N.V. Verto, Netherlands, was employed. As webs 31 and 33, 20 g/m^2 webs of commercially available Chisso bonded rayon nonwoven fabric were employed.

Dual rotor machine 29 was operated to produce from web 28 a random barrier web 30 of 25 g/m^2 under the following conditions.

Air-flow	: 198 m^3/min (7000 ft^3/min)
Diameter of feed-roller	: 8.9 cm (3.5 inch)
Diameter of lickerin	: 22.9 cm (9.0 inch)
Gap between feed-roller and nose-bar	: 0.013 cm (0.005 inch)
Gap between lickerin and nose-bar	: 0.038 cm (0.015 inch)
Gap between lickerin and doctor-blade	: 0.03 to 0.038 cm (0.012 to 0.015 inch)
Suction fan	: 5.08 cm (2 inch) mercury
Speed of carrier web 31 in relation to feed roller	: x5
Temperature of calendering rolls	: 95°C

The three-ply laminar web produced was processed into disposable surgical apparel as described above with reference to Figures 1 to 7.

The air resistance of the laminar web was determined by passing air at a flow rate of 85 litres per minute through 115 cm^2 (17.8 inch^2) of the web. The pressure drop, in mm of water, between the upstream and downstream sides of the test web is a measure of the air resistance of the web. The air resistance of the web was found to be negligible, i.e. a back pressure of less than 1 mm of water.

The bacterial filtration efficiency (BFI) of the web was determined to be extremely high.

CLAIMS:

1. An item of disposable apparel comprising, as a protective barrier layer, a web comprising electret fibers having an average width or diameter of at least 10 microns, the electret fibers in said web having a weight of not more than 75 g/m^2.

2. An item of disposable apparel according to Claim 1 wherein the electret fibers in said web have a weight of not more than 50 g/m^2.

3. An item of disposable apparel according to Claim 1 or Claim 2 wherein said electret fibers are fibrillated electret fibers having an average width of at least 10 microns.

4. An item of disposable apparel according to any one of Claims 1 to 3 wherein said web consists of said electret fibers.

5. An item of disposable apparel according to any one of Claims 1 to 4 wherein said apparel further comprises support means for the protective barrier layer.

6. An item of disposable apparel according to Claim 5 wherein said support means comprises at least one web of nonwoven fabric supporting said protective barrier layer.

7. An item of disposable apparel according to any one of Claims 1 to 6 wherein said electret fibers are polypropylene electret fibers.

8. A method of producing an item of disposable apparel including the step of providing a protective barrier layer by laying one or more webs comprising electret fibers or electret-precursor fibers, said fibers having, in said web or combined webs, a total weight of not more than 75 g/m^2 and the fibers having an average width or diameter of at least 10 microns.

9. A method of producing an item of disposable apparel including the steps of laying, on a first web of nonwoven fabric, one or more webs comprising electret fibers or electret-precursor fibers, said fibers having, in said web or combined webs, a total weight of not more than 75 g/m^2 and the fibers having an average width or diameter of at least 10 microns, and optionally laying a second web of nonwoven fabric on said one or more webs of electret or

electret-precursor fibers, and processing the formed laminar web into said item of disposable apparel.

10. A method according to Claim 8 or Claim 9 wherein said fibers are fibrillated fibers.

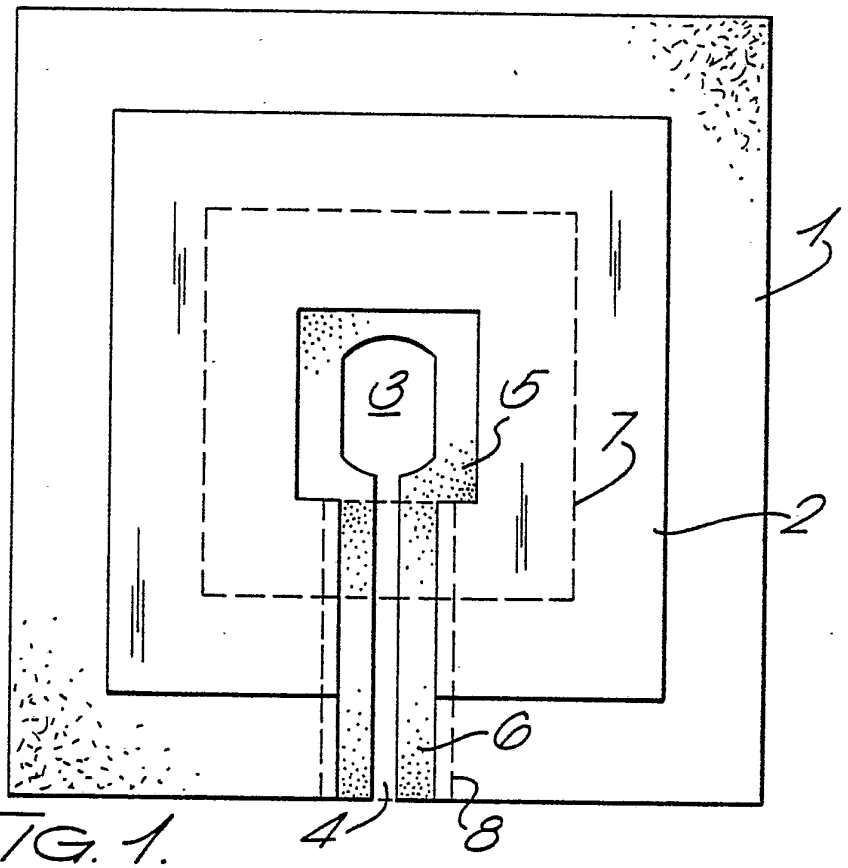


FIG. 1.

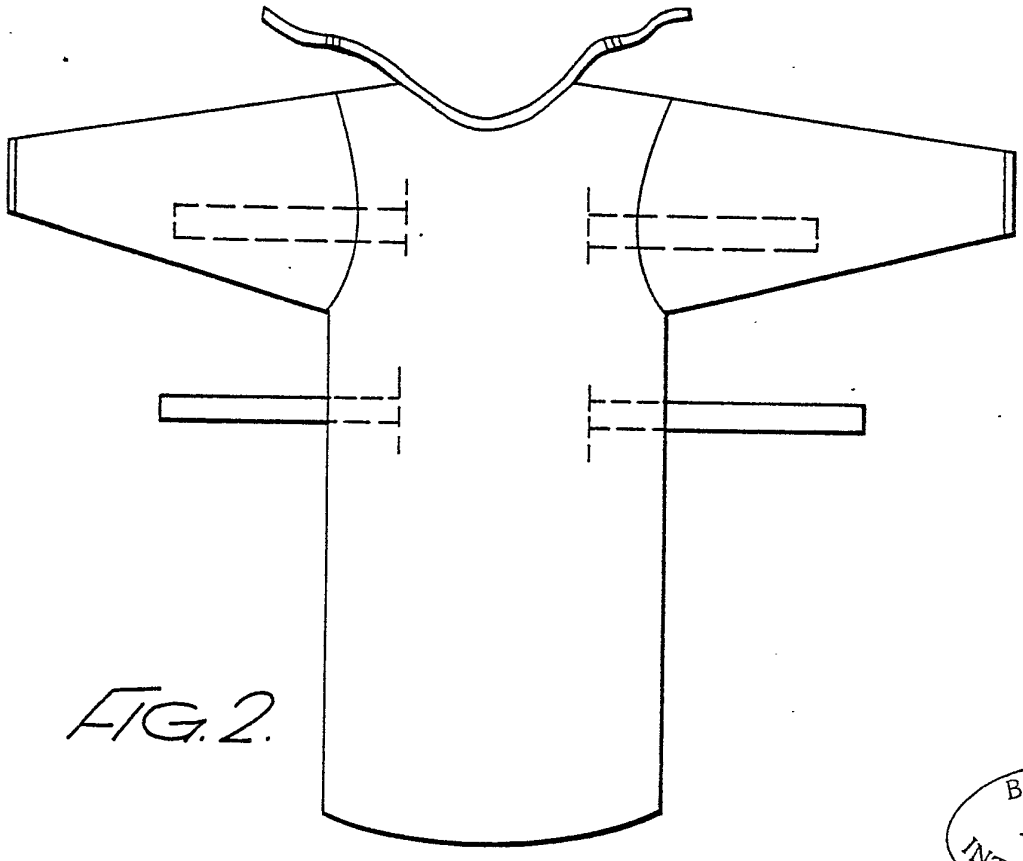


FIG. 2.

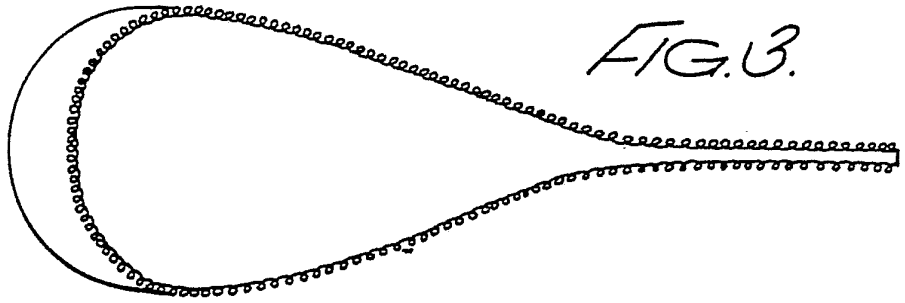


FIG. 3.

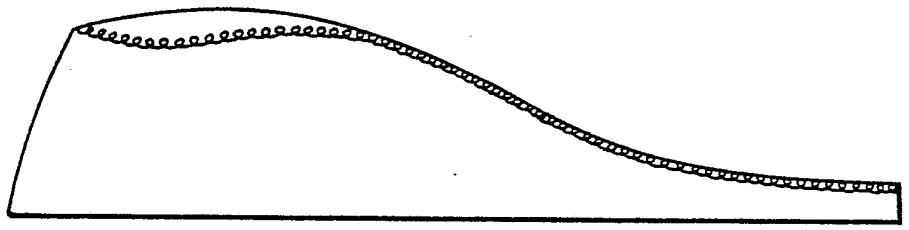
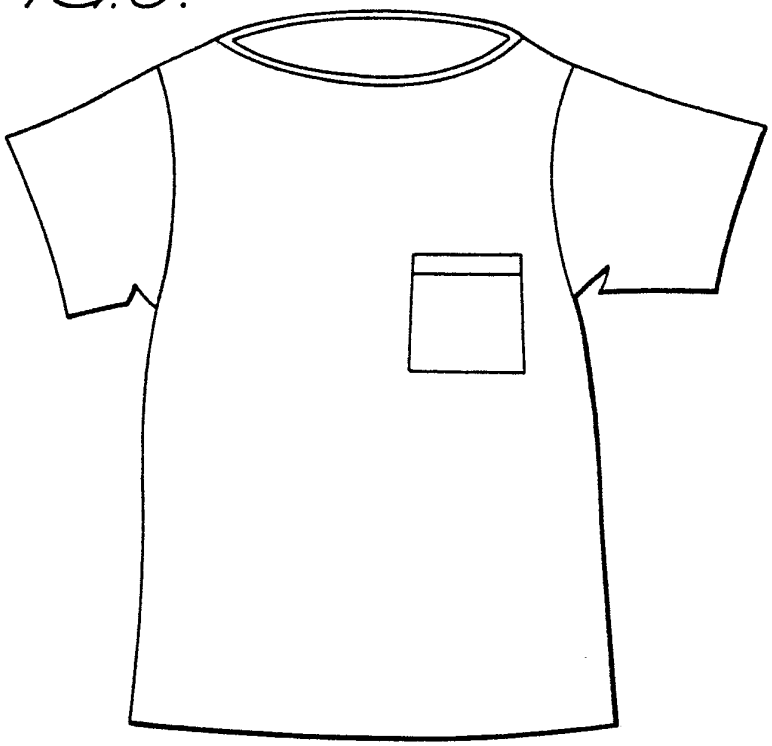


FIG. 4.

FIG. 5.



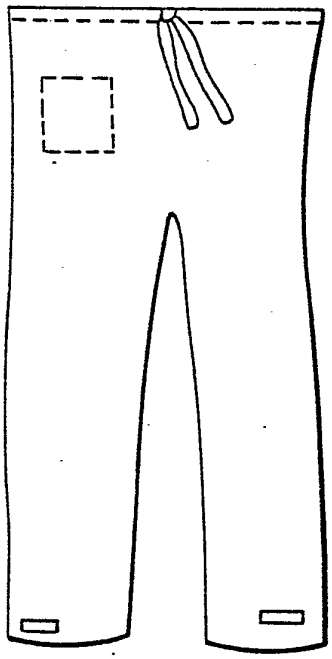


FIG. 6.

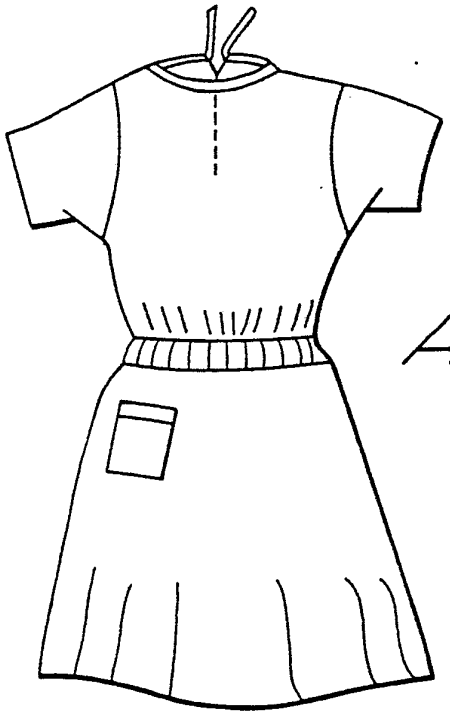


FIG. 7.

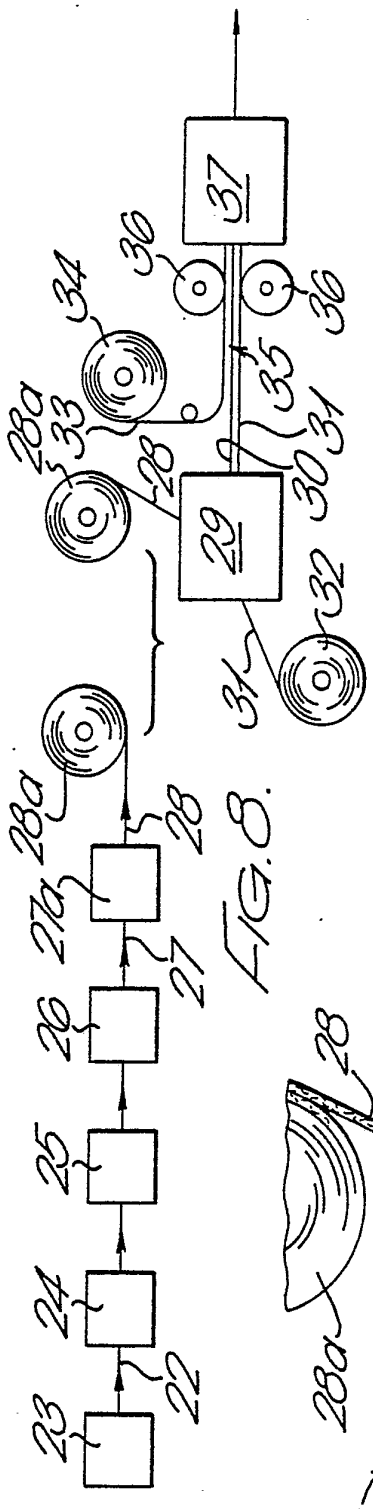


FIG. 8.

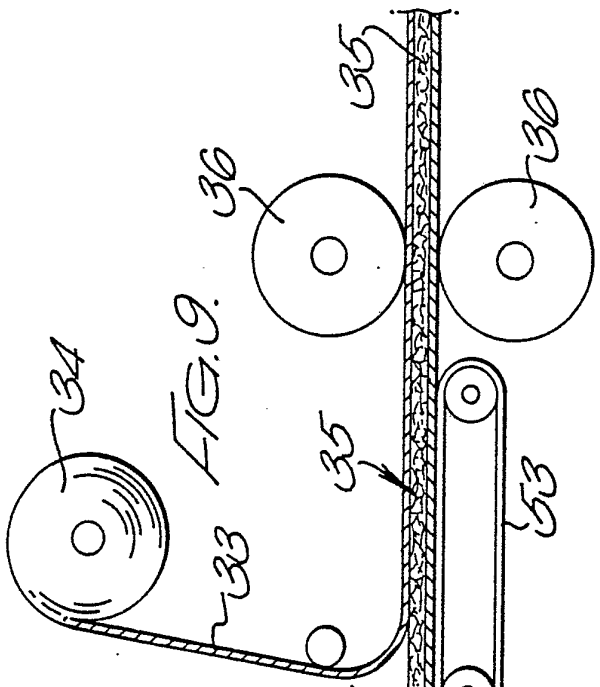
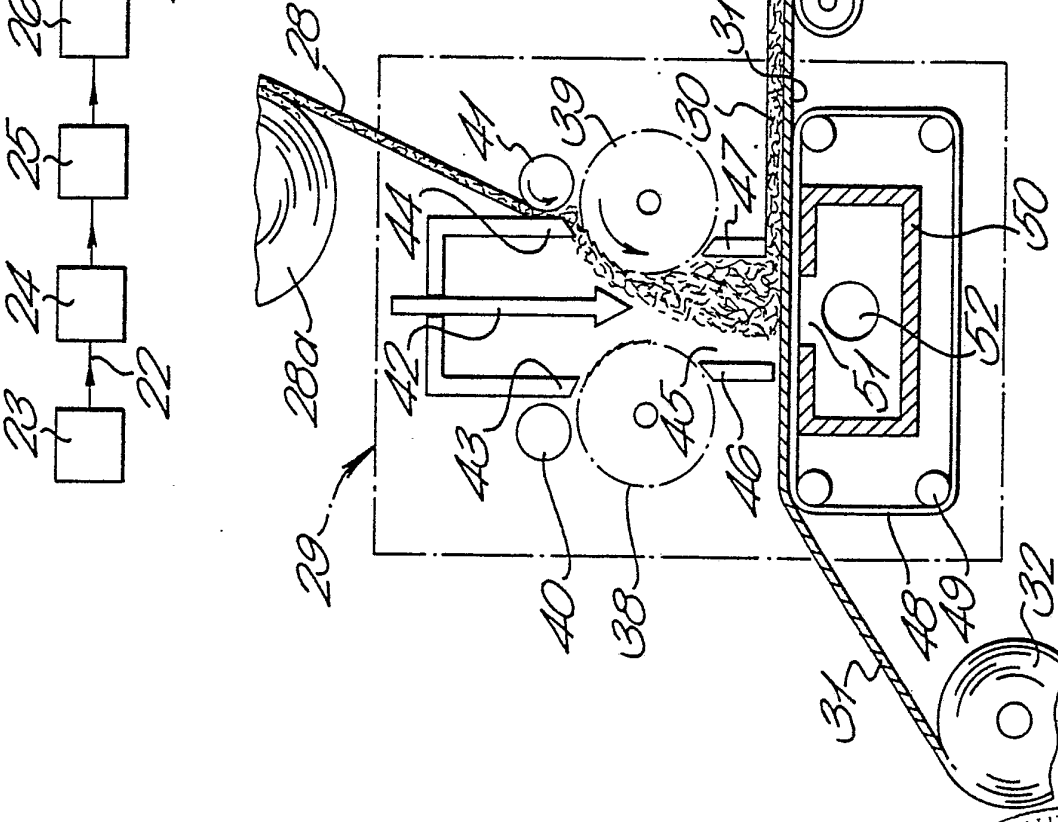


FIG. 9.



INTERNATIONAL SEARCH REPO.

International Application No PCT/GB 81/00086

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.[3] A 41 D 13/00; B 01 D 39/16; D 04 H 13/00

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
Int.Cl.[3]	A 41 D 13/00; B 01 D 39/16; D 04 H 13/00; D 04 H 1/56

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO SE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [13]
	GB, A, 2014059, published 22nd August 1979, see the whole document, Martindale --	1,4-7
	FR, A, 2416535, published 31st August 1979, see claims 1-11, Minnesota corresponding to GB, A, 2015253	1,4-7

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [1]	Date of Mailing of this International Search Report [2]
11st August 1981	21st August 1981

International Searching Authority [1]	Signature of Authorized Officer [20]
EUROPEAN PATENT OFFICE Branch at The Hague P.O.Box 5818 Patentlaan ,2 2280 HV RIJSWIJK (ZH) The Netherlands	G.L.M. Kruydenberg