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**(54) PRINTING PROCESS FOR PATTERNED WRAPPER PAPER**

DRUCKVERFAHREN FÜR GEMUSTERTES EINWICKELPAPIER

PROCÉDÉ D'IMPRESSION DESTINÉ À UN PAPIER D'ENROBAGE PRÉSENTANT DES MOTIFS

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**Description**

## FIELD OF THE DISCLOSURE:

**[0001]** This disclosure relates generally to a process for making cigarette wrapper paper having an applied pattern of add-on material. More particularly, the disclosure concerns a process for making cigarette wrapper paper with a specially formulated oxidized starch material. From US 2007/0102017 is a prior art process for making patterned wrapper paper known, the process including preparing a printing solution including at least water and an oxidized starch.

## SUMMARY:

**[0002]** A wrapper paper for cigarettes may be fashioned with a pattern of add-on material to reduce the ignition propensity characteristics of a smoking article fashioned using the wrapper. Reduced ignition propensity characteristics reflect a lowered capability of a smoking article to cause a substrate to ignite when a smoldering smoking article is left inadvertently unattended on a substrate.

**[0003]** In accordance with this disclosure, a predetermined pattern of add-on material containing an aqueous starch solution may be applied to a base web of wrapper paper. The predetermined pattern may comprise a plurality of transverse bands, a plurality of longitudinal bands, a two-dimensional array of treated regions, or any other suitable pattern. Preferably, the predetermined pattern may be applied using a printing technique, such as, for example, gravure printing, offset printing, inkjet printing, spraying, die printing, or the like. Most preferably, gravure printing may be used.

**[0004]** To improve the ignition propensity characteristics of a smoking article fashioned from the wrapper paper, the pattern is preferably applied with a printing solution containing an oxidized starch as set out in claim 1. Desired printing characteristics are attained using an aqueous starch solution having a room temperature viscosity no greater than about 50mPa·s (centipoise, cP), and prepared from particles having a size in the range of about 4 microns to about 40 microns when dry, and about 90% of the particles having a size in the range of about 10 microns to about 100 microns when wet. Moreover, the starch solution is slightly acidic with a pH in the range of about 6 to about 6.5. Starch employed for the printing solution preferably may be mixed with water to form a printing solution having a starch concentration of about 20% to about 24% (by weight). Another characteristic of the printing solution is a relatively high surface tension, for example, on the order of  $6.5 \cdot 10^{-2} \text{Nm}^{-1}$  (65 dynes/centimeter) or more.

**[0005]** If desired, the printing solution may be applied to the base web in two or more layers. Those layers may be vertically registered with one another, offset from one another, have portions spaced from one another, and the

like. Furthermore, a conventional filler material, such as calcium carbonate, may be included in one or more of the layers, as may be desired.

## 5 BRIEF DESCRIPTION OF THE DRAWINGS:

**[0006]** Many objects and advantages of this disclosure will be apparent to those skilled in the art when this written description is read in conjunction with the accompanying drawings wherein like reference numerals are applied to like elements and wherein:

FIG. 1 is a schematic view of a gravure printing process;

15 FIG. 2 is a schematic view of a wrapper paper having transversely printed regions;

FIG. 3 is a schematic view of a wrapper paper having longitudinally printed regions;

20 FIG. 4 is a schematic view of a wrapper paper having a two-dimensional pattern;

FIG. 5 is cross-sectional view of a multilayer printed region; and

25 FIG. 6 is a perspective view of a smoking article having a tobacco rod constructed with the wrapper disclosed herein.

## DETAILED DESCRIPTION:

**[0007]** Generally, a predetermined pattern of add-on material may be applied to a base web of a wrapper paper to obtain improved Ignition Propensity ("IP") characteristics and also to obtain improved Self-Extinguishment ("SE") characteristics. Ignition Propensity is a standard test conducted as set forth in ASTM E 2187--04, "Standard Test Method for Measuring the Ignition Strength of Smoking articles". Ignition propensity measures the probability that a smoking article, when placed on a substrate, will generate sufficient heat to maintain static burning of the tobacco rod. Low values for IP are desirable as such values correlate with a reduced likelihood that a smoldering smoking article will cause combustion in an underlying substrate.

**[0008]** Furthermore, the predetermined pattern of add-on material is typically applied to a base web having a permeability lying in the range of about 20 to about 80 CORESTA units. When dry, the add-on material often forms a film on the base web that is effective to locally reduce permeability to values lying in the range of 0 to about 10 CORESTA units. In some applications, the add-on material is applied as an aqueous solution including starch.

**[0009]** Unexpectedly, it has been found that certain characteristics of the starch material give rise to predetermined patterns that yield very low Ignition Propensity values when the patterned base paper is formed into smoking articles. Even more surprising has been the realization that within the standard specifications for some well-known starch materials, batch-to-batch variations in

material properties can affect the Ignition Propensity of the resulting smoking articles. By way of example, the specifications of an oxidized tapioca starch commercially offered by National Starch & Chemical Co. as Flo-Max 8 indicate a pH in a 1% solution lying in the range of 4.5 to 6.5, with particles having molecular weights in excess of 10,000. Surprisingly, when a predetermined pattern was applied to a base web with a batch of Flo-Max 8 having a pH in the range of about 6 to about 6.5, Ignition Propensity has been found to be much improved when compared to other batches of Flo-Max 8 for which the pH was less than about 6 but still within the manufacturer's specifications.

**[0010]** Various balances or trade-offs need to be made in selection of starch parameters for use in applying films to wrapper paper. For example, while high molecular weight starch may give rise to effective permeability reduction, such high molecular weight starches must be used in low concentrations, resulting in a solution having a very high water content. But high-water-content films are much more difficult to effectively dry on porous wrapper paper. Moreover, it has been found that surface tension of the starch solution affects the retention of small bubbles of air -- low surface tension allows smaller bubbles to remain in the solution, whereas high surface tension causes bubbles to agglomerate and separate out of the solution giving a more uniform and consistent material for application to the wrapper paper.

**[0011]** Although not fully understood, the preferred pH range of the oxidized starch is believed to reflect a lower degree - or less complete -- oxidation of the starch polymer chains giving more, longer polymer chains than the more acidic (i.e., lower pH) starches.

**[0012]** Furthermore, longer polymer chains yield a solution having a higher viscosity. Higher viscosity for the starch solution translates to better control when applied to a wrapper paper in a printing process.

**[0013]** Based on these understandings, it has been found that marked improvement in the Ignition Propensity of patterned wrapper paper results for starch solutions having particular, and improved, characteristics. Those characteristics for an aqueous solution including oxidized starch include a pH in the range of about 6 to about 6.5; a surface tension of at least about  $6.5 \cdot 10^{-2} \text{Nm}^{-1}$  (65 dynes/centimeter); a room temperature viscosity of no greater than about 50 mPa·s; and a particle size distribution in the range of about 4 microns to about 40 microns for dry particles, with about 90% also being in the range of about 10 microns to about 100 microns when wet. Furthermore, the particles preferably have a molecular weight such that the solution can have starch concentrations in the range of about 20% to about 24%. Preferably, the starch comprises an oxidized tapioca starch.

**[0014]** The aqueous starch solutions used for application to the base web or wrapper paper are typically prepared by making a starch/water mixture by first mixing the desired weight of dry starch powder with the desired weight of room temperature water (i.e., at about 15°C to

about 25°C) to obtain a starch/water mixture having the preselected concentration. For example, to prepare a starch/water solution with a preselected concentration of 20%, 20 parts by weight of starch are mixed with 80 parts by weight of water. The starch/water solution is then heated to an elevated sub-boiling temperature in the range of about 90°C to about 95°C - i.e., below the boiling temperature. The starch/water solution is held at the elevated temperature for about 20 to about 30 minutes for thermal soaking. Then, the starch/water solution is cooled to room temperature. That cooling step can occur by passively, such as by naturally occurring heat transfer processes; or the cooling step can be active (or forced) such as by immersion in a cooling bath or by use of a conventional mechanical cooling system. Throughout the mixing step, the heating step, the thermal soaking step, and the cooling step, the starch/water mixture is stirred. The stirring can be continuous or substantially continuous. If additional constituents, such as calcium carbonate, are to be incorporated into the starch/water solution, those constituents should be added after the starch/water solution returns to room temperature following the thermal soaking step.

**[0015]** Aqueous starch solutions having the characteristics specified above and prepared in the manner described above can be applied to a base web using any of a multitude of printing techniques including, by way of example and without limitation, the group consisting of gravure printing, offset printing, inkjet printing, spraying, and die printing. Other printing processes may also be suitable and are intended to lie within the teachings of this specification. Preferably, however, gravure printing may be used to apply the starch solution to a base web to obtain a patterned wrapper paper.

**[0016]** For example, (see FIG. 1), a base web of wrapper paper 10 may be fed from a bobbin 12 into a gravure printing system 14 where a predetermined pattern of starch solution prepared in accord with the foregoing specification is applied to the base web 10. The base web 10, with the newly applied predetermined pattern is collected on a collection bobbin 16. In otherwise conventional steps, the bobbin 16 of patterned wrapper paper may be used to fashion tobacco rods for use in making smoking articles, such as cigarettes.

**[0017]** The gravure printing system 14 may include one, two, three, or more printer operations 14a, 14b, 14c. As these operations are essentially the same, it will suffice to describe details of one with the understanding that the others have corresponding details. The starch solution described above may be furnished to a reservoir 20 from which it is pumped or otherwise supplied to a gravure roll 22 having a patterned surface. That roll 22 rotates in a bath of the starch solution. As the gravure roll 22 rotates, the starch solution is wiped from the roll surface by a doctor blade assembly 23 so that, as the gravure roll 22 contacts the base web 10 at the nip between the gravure roll 22 and the resiliently faced backing roll 24, the starch solution transfers to the base web with the

pattern on the surface of the gravure roll 22.

**[0018]** After suitable drying, the base web 10 may advance to one or more other print operations 14b, 14c where one or more additional layers of starch material in the same or different predetermined patterns may be applied to the base web 10. If desired, the starch material in other print operations may include other constituents, for example, calcium carbonate. Furthermore, if desired, the starch solution having calcium carbonate could be applied in the first printing operation 14a, while the starch solution without calcium carbonate may be applied in the second or successive printing operation 14b, 14c.

**[0019]** The base web 10 (see FIG. 2) typically has a transverse or cross-web direction (shown by the arrow 30) as well as a longitudinal direction (shown by the arrow 32). The predetermined pattern of add-on material may comprise a plurality of transversely oriented, generally parallel, regions or bands 34. These bands may be uniformly spaced along the length of the base web 10, or may be arranged at recurrent spacing patterns related to tobacco rod length and finished cigarette fabrication.

**[0020]** Alternatively, the base web 10 may include a predetermined pattern such as one or more longitudinally extending regions or stripes 36 (see FIG. 3) of add-on material. If desired, the predetermined pattern may also comprise a two-dimensional array of regions 38 (see FIG. 4) of add-on material spaced along and/or transversely of the base web 10.

**[0021]** Furthermore, as noted above, the add-on material can be applied in two or more layers 40, 42 (see FIG. 5). The layers can be fully registered and co-extensive with one another if so desired. Alternatively, the upper layer 42 may be split or slit into two portions 42a, 42b, each of which is superposed on the first or lower layer 40 such that a space exists between the two portions 42a, 42b. That space may extend either longitudinally or transversely on the base web 10. In a further alternative, the upper layer 42 may be superposed on the lower layer 40, but not co-extensive therewith.

**[0022]** A smoking article (see FIG. 6) comprises a tobacco rod 205 and a filter 207, which are attached to one another with a tipping paper 209. The tobacco rod 205 includes a wrapper 210 that is constructed in accordance with the teachings herein.

**[0023]** When the word "about" is used in this specification in connection with a numerical value, it is intended that the associated numerical value include a tolerance of  $\pm 10\%$  around the stated numerical value. Moreover, when reference is made to percentages in this specification, it is intended that those percentages are based on weight, i.e., weight percentages.

**[0024]** It will now be apparent that a new, improved, and nonobvious process for making patterned wrapper paper has been described in this specification with sufficient particularity as to be understood by one of ordinary skill in the art. Moreover, it will be apparent to those skilled in the art that numerous modifications, variations, substitutions, and equivalents exist for features of the inven-

tion which do not materially depart from the spirit and scope of the invention. Accordingly, it is expressly intended that all such modifications, variations, substitutions, and equivalents which fall within the spirit and scope of the invention as defined by the appended claims shall be embraced by the appended claims.

## Claims

1. A process for making patterned wrapper paper comprising the steps of:

preparing a printing solution including at least water and an oxidized starch having:

room temperature viscosity no greater than about 50 centipoises (50 mPa·s);  
particles in the range of about 4 to about 40 microns when dry and about 90% in the range of about 10 microns to about 100 microns when wet; and  
a pH in the range of about 6 to about 6.5,

the starch further being capable of forming a printing solution with about 20% to about 24% by weight oxidized starch content and the printing solution having a surface tension of at least about 65 dynes per centimeter ( $6.5 \cdot 10^{-2} \text{Nm}^{-1}$ ); and

providing a base web of wrapper paper;  
applying the printing solution to the wrapper paper in a predetermined pattern.

2. A process according to claim 1 wherein the base web has a transverse direction and wherein the predetermined pattern comprises a plurality of bands extending generally transversely on the base web.

3. A process according to claim 2 wherein the plurality of bands are regularly spaced from one another along the base web.

4. A process according to claim 1, 2 or 3 wherein the base web has a longitudinal direction and wherein the predetermined pattern includes at least one longitudinally extending stripe.

5. A process according to any preceding claim wherein the base web has a transverse direction and a longitudinal direction and wherein the predetermined pattern includes a plurality of regions spaced transversely and longitudinally on the base web.

6. A process according to any preceding claim wherein the printing solution is applied in two or more layers to the base web.

7. A process according to any preceding claim wherein the printing solution further includes calcium carbonate.
8. A process according to any preceding claim wherein the step of preparing a printing solution includes:
- mixing a predetermined quantity of dry starch with a predetermined quantity of room temperature water;
- heating the mixture of starch and water to a sub-boiling temperature;
- maintaining the mixture of starch and water at the sub-boiling temperature for a time period in the range of about 20 to about 30 minutes;
- allowing the mixture of starch and water to return to room temperature; and
- stirring the mixture of starch and water at least substantially continuously during the step of preparing.
9. A process according to claim 8 wherein the sub-boiling temperature is a temperature in the range of about 90°C to 95°C.
10. A process according to claim 8 or 9 wherein the step of allowing the mixture of starch and water to return to room temperature includes the step of active cooling.
11. A process according to claim 8 or 9 wherein the step of allowing the mixture of starch and water to return to room temperature includes the step of passive cooling.
12. A process according to claim 8, 9, 10 or 11 further including the step of adding at least one additional constituent to the mixture of starch and water after the mixture returns to room temperature.
13. A process according to claim 12 wherein the additional constituent is calcium carbonate.
14. A process according to any preceding claim wherein the starch comprises an oxidized tapioca starch.
15. A process for making a tobacco rod for a smoking article comprising patterned wrapping paper, comprising the steps of:
- making a patterned wrapper paper by a process according to any preceding claim; and
- using the said patent wrapper to make a tobacco rod.
16. A process for making a smoking article comprising making a tobacco rod by a process according to claim 15 and attaching the said tobacco rod to a filter

with a tipping paper.

### Patentansprüche

1. Verfahren für das Herstellen von gemustertem Hüllpapier, folgende Schritte umfassend:
- Vorbereiten einer Drucklösung, die mindestens Wasser und eine oxidierte Stärke beinhaltet, Folgendes aufweisend:
- Viskosität bei Raumtemperatur von höchstens 50 Zentipoise (50 mPa s);
- Partikel im Bereich von etwa 4 bis etwa 40 Mikron im trockenen Zustand und etwa 90 % im Bereich von etwa 10 Mikron bis etwa 100 Mikron im nassen Zustand; und
- einen pH-Wert im Bereich von etwa 6 bis etwa 6,5,
- wobei die Stärke ferner in der Lage ist, eine Drucklösung mit etwa 20 bis etwa 24 Gewichtsprozent oxidiertem Stärkegehalt auszubilden und die Drucklösung eine Oberflächenspannung von mindestens etwa 65 Dyn pro Zentimeter ( $6.5 \cdot 10^{-2} \text{Nm}^{-1}$ ) aufweist; und
- Bereitstellen einer Grundbahn des Hüllpapiers; Auftragen der Drucklösung auf das Hüllpapier in einem vorher festgelegten Muster.
2. Verfahren nach Anspruch 1, wobei die Grundbahn eine Querrichtung hat und wobei das vorher festgelegte Muster eine Vielzahl von Bändern umfasst, die sich im Allgemeinen quer auf der Grundbahn erstrecken.
3. Verfahren nach Anspruch 2, wobei die Vielzahl von Bändern entlang der Grundbahn regelmäßig voneinander beabstandet sind.
4. Verfahren nach Anspruch 1, 2 oder 3, wobei die Grundbahn eine Längsrichtung hat und wobei das vorher festgelegte Muster mindestens einen sich längs erstreckenden Streifen beinhaltet.
5. Verfahren nach einem der vorstehenden Ansprüche, wobei die Grundbahn eine Querrichtung und eine Längsrichtung hat und wobei das vorher festgelegte Muster eine Vielzahl von Regionen beinhaltet, die auf der Grundbahn quer und längs beabstandet sind.
6. Verfahren nach einem der vorstehenden Ansprüche, wobei die Drucklösung in ein oder zwei Schichten auf die Grundbahn aufgetragen wird.
7. Verfahren nach einem der vorstehenden Ansprüche, wobei die Drucklösung ferner Kalziumkarbonat be-

inhaltet.

8. Verfahren nach einem der vorstehenden Ansprüche, wobei der Schritt des Vorbereitens einer Drucklösung Folgendes umfasst:

Mischen einer vorher festgelegten Menge trockener Stärke mit einer vorher festgelegten Menge von Wasser mit Raumtemperatur; Erwärmen des Gemischs aus Stärke und Wasser auf eine Temperatur unter dem Siedepunkt; Halten des Gemischs aus Stärke und Wasser auf der Temperatur unter dem Siedepunkt für einen Zeitraum im Bereich von etwa 20 bis etwa 30 Minuten;

Ermöglichen, dass das Gemisch aus Stärke und Wasser auf Raumtemperatur zur Raumtemperatur zurückzukehren kann; und Rühren des Gemischs aus Stärke und Wasser mindestens im Wesentlichen kontinuierlich während des Schritts des Vorbereitens.

9. Verfahren nach Anspruch 8, wobei die Temperatur unter dem Siedepunkt eine Temperatur im Bereich von etwa 90 °C bis etwa 95 °C ist.

10. Verfahren nach Anspruch 8 oder 9, wobei der Schritt des Ermöglichens des Gemischs aus Stärke und Wasser, zur Raumtemperatur zurückzukehren, den Schritt aktiver Kühlung beinhaltet.

11. Verfahren nach Anspruch 8 oder 9, wobei der Schritt des Ermöglichens des Gemischs aus Stärke und Wasser, zur Raumtemperatur zurückzukehren, den Schritt passiver Kühlung beinhaltet.

12. Verfahren nach Anspruch 8, 9, 10 oder 11, ferner beinhaltend den Schritt des Hinzufügens mindestens eines zusätzlichen Bestandteils zum Gemisch aus Stärke und Wasser, nachdem das Gemisch zur Raumtemperatur zurückgekehrt ist.

13. Verfahren nach Anspruch 12, wobei der zusätzliche Bestandteil Kalziumkarbonat ist.

14. Verfahren nach einem der vorstehenden Ansprüche, wobei die Stärke eine oxidierte Tapiokastärke umfasst.

15. Verfahren für das Herstellen eines Tabakstrangs für einen Rauchartikel, umfassend gemustertes Hüllpapier, folgende Schritte umfassend:  
Herstellen eines gemusterten Hüllpapiers durch ein Verfahren gemäß einem der vorstehenden Ansprüche; und  
Verwenden der patentierten Hülle, um einen Tabakstrang herzustellen.

16. Verfahren für das Herstellen eines Rauchartikels, umfassend das Herstellen eines Tabakstrangs durch ein Verfahren nach Anspruch 15 und Anbringen des Tabakstrangs an einem Filter in einem Belegpapier.

## Revendications

1. Procédé pour la fabrication de papier d'enveloppe à motifs comprenant les étapes de :

la préparation d'une solution d'impression incluant au moins de l'eau et un amidon oxydé ayant :

une viscosité à température ambiante qui n'est pas supérieure à environ 50 centipoises (50 mPa·s) ;

des particules dans la gamme d'environ 4 à environ 40 micromètres lorsqu'elles sont sèches et environ 90 % dans la gamme d'environ 10 micromètres à environ 100 micromètres lorsqu'elles sont humides ; et un pH dans la gamme d'environ 6 à environ 6,5,

l'amidon étant capable en outre de former une solution d'impression avec environ 20 % à environ 24 % en poids de teneur en amidon oxydé et la solution d'impression ayant une tension superficielle d'au moins environ 65 dynes par centimètre ( $6,5 \cdot 10^{-2} \text{Nm}^{-1}$ ) ; et

la fourniture d'une bande de base de papier d'enveloppe ;  
l'application de la solution d'impression au papier d'enveloppe selon un motif prédéterminé.

2. Procédé selon la revendication 1, dans lequel la bande de base a une direction transversale et dans lequel le motif prédéterminé comprend une pluralité de bandes s'étendant généralement de manière transversale sur la bande de base.

3. Procédé selon la revendication 2, dans lequel la pluralité de bandes sont régulièrement espacées l'une de l'autre le long de la bande de base.

4. Procédé selon la revendication 1, 2 ou 3, dans lequel la bande de base présente une direction longitudinale et dans lequel le motif prédéterminé inclut au moins une bande s'étendant longitudinalement.

5. Procédé selon l'une quelconque revendication précédente, dans lequel la bande de base a une direction transversale et une direction longitudinale et dans lequel le motif prédéterminé inclut une pluralité de zones espacées transversalement et longitudi-

- nalement sur la bande de base.
6. Procédé selon l'une quelconque revendication précédente, dans lequel la solution d'impression est appliquée dans deux ou plusieurs couches sur la bande de base. 5
7. Procédé selon l'une quelconque revendication précédente, dans lequel la solution d'impression inclut en outre du carbonate de calcium. 10
8. Procédé selon l'une quelconque revendication précédente, dans lequel l'étape de préparation d'une solution d'impression inclut :
- le mélange d'une quantité prédéterminée d'amidon sec à une quantité prédéterminée d'eau à température ambiante ;
  - le chauffage du mélange d'amidon et d'eau à une température sous l'ébullition ; 20
  - le maintien du mélange d'amidon et d'eau à la température sous l'ébullition pendant une période de temps dans la gamme d'environ 20 à environ 30 minutes ;
  - l'autorisation au mélange d'amidon et d'eau de revenir à la température ambiante ; et 25
  - l'agitation du mélange d'amidon et d'eau au moins de manière sensiblement continue pendant l'étape de préparation. 30
9. Procédé selon la revendication 8, dans lequel la température sous l'ébullition est une température se trouvant dans la gamme d'environ 90 °C à 95 °C.
10. Procédé selon la revendication 8 ou 9, dans lequel l'étape d'autorisation au mélange d'amidon et d'eau de revenir à la température ambiante inclut l'étape de refroidissement actif. 35
11. Procédé selon la revendication 8 ou 9, dans lequel l'étape d'autorisation au mélange d'amidon et d'eau de revenir à la température ambiante inclut l'étape de refroidissement passif. 40
12. Procédé selon la revendication 8, 9, 10 ou 11, incluant en outre l'étape d'ajout d'au moins un constituant supplémentaire au mélange d'amidon et d'eau après que le mélange soit revenu à température ambiante. 45
13. Procédé selon la revendication 12, dans lequel le constituant supplémentaire est du carbonate de calcium. 50
14. Procédé selon l'une quelconque revendication précédente, dans lequel l'amidon comprend un amidon oxydé de tapioca. 55
15. Procédé pour la fabrication d'une tige de tabac pour un article à fumer comprenant du papier d'enveloppe à motifs, comprenant les étapes de :
- la fabrication d'un papier d'enveloppe à motifs grâce à un processus selon l'une quelconque revendication précédente ; et
  - l'utilisation dudit enveloppe à motifs pour fabriquer une tige de tabac.
16. Procédé pour la fabrication d'un article à fumer comprenant la fabrication d'une tige de tabac grâce à un processus selon la revendication 15 et la fixation de ladite tige de tabac à un filtre avec du papier manchette.



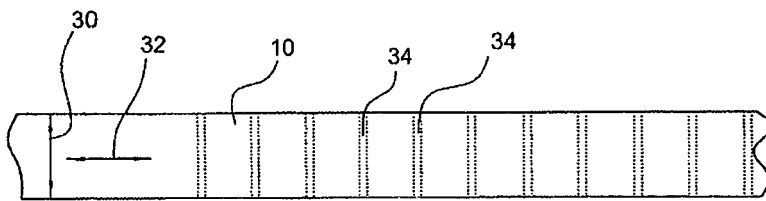


FIG. 2

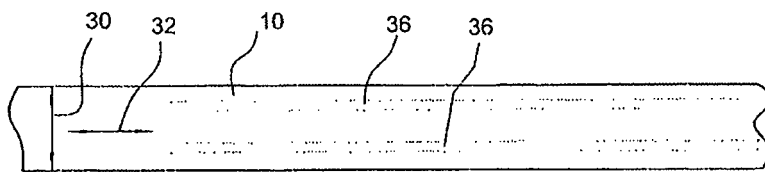


FIG. 3

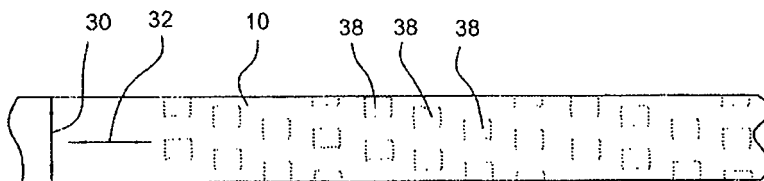


FIG. 4

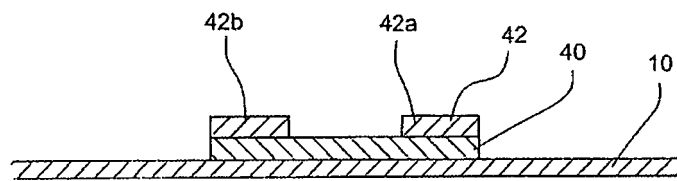
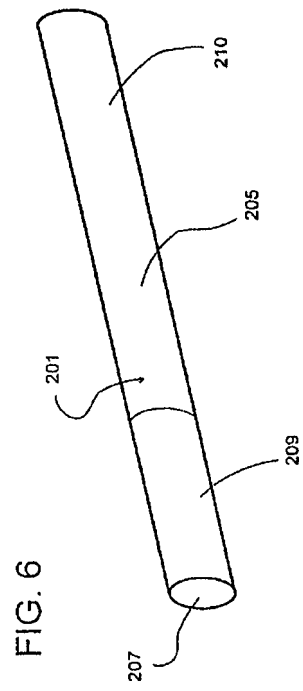


FIG. 5



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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