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(54) Titre : PROCEDE POUR REALISER DES MARQUES TACTILES SUR UN SUBSTRAT
(54) Title: METHOD FOR MAKING TACTILE MARKS ON A SUBSTRATE

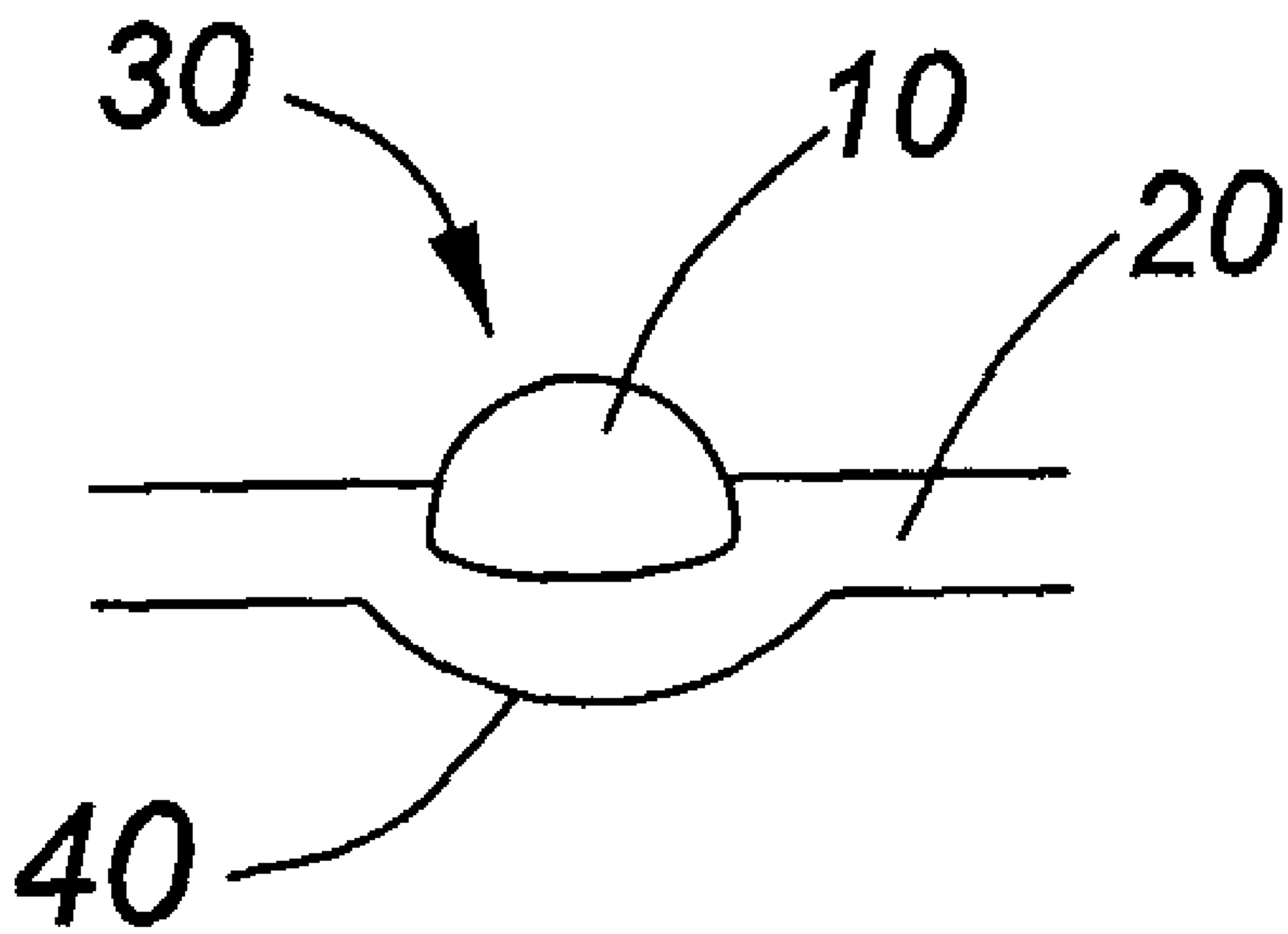

FIG. 4

(57) Abrégé/Abstract:
Durable, easily recognizable and easy-to-feel tactile marks are provided which may be incorporated into security documents, such as banknotes, to assist visually impaired people in validating such security documents. Deposits are printed onto the substrate,

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(57) Abrégé(suite)/Abstract(continued):
using an ink, resin or ink-like printing material, in a predetermined pattern to form tactile marks adhering to the substrate. A sufficiently high pressure is applied to the substrate with the printed tactile marks to calender the tactile marks, thereby forming corresponding protrusions in the substrate on the opposite sides of the printed tactile marks. An energy curable printing material may be used to print the deposits and the calendering of the tactile marks may be performed by intaglio printing.

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(54) Title: METHOD FOR MAKING TACTILE MARKS ON A SUBSTRATE

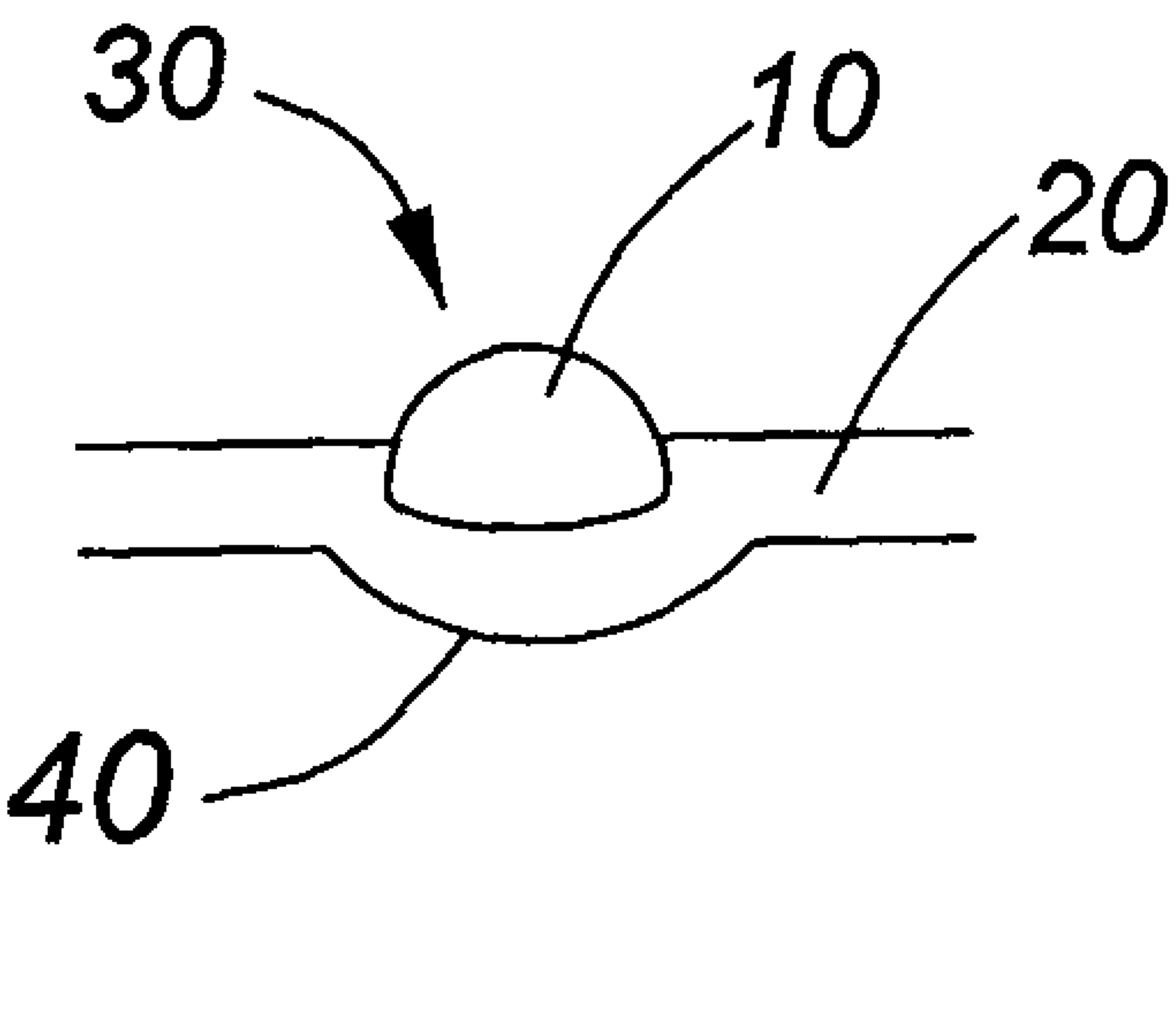

FIG. 4

(57) Abstract: Durable, easily recognizable and easy-to-feel tactile marks are provided which may be incorporated into security documents, such as banknotes, to assist visually impaired people in validating such security documents. Deposits are printed onto the substrate, using an ink, resin or ink-like printing material, in a predetermined pattern to form tactile marks adhering to the substrate. A sufficiently high pressure is applied to the substrate with the printed tactile marks to calender the tactile marks, thereby forming corresponding protrusions in the substrate on the opposite sides of the printed tactile marks. An energy curable printing material may be used to print the deposits and the calendering of the tactile marks may be performed by intaglio printing.

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METHOD FOR MAKING TACTILE MARKS ON A SUBSTRATE

FIELD OF THE INVENTION

The invention relates to the field of printing and, more particularly, to improved methods for printing tactile marks for the visually impaired onto security documents (e.g. banknotes).

BACKGROUND

There is a need and desire to incorporate physical features into products handled by visually impaired people so that they can discern certain characteristics relating to such products. For example, it is important that visually impaired people be able to distinguish and use products such as security documents, in particular, different denominations of banknotes. For this purpose, currency-issuing national banks are implementing various features in the production of banknotes. Examples include varying the size of banknotes and printing tactile marks, such as Braille markings or deep intaglio patterns and non-intaglio, deep embossments on the banknotes which may be discerned by touch (i.e. by the user feeling the document in the area of such marks, patterns and embossments). However, in order to be effective and acceptable for use in the marketplace, printed tactile markings must provide durable, effective tactility for users for the expected life time of the banknote. Those known and used to date for use by the visually impaired have been found to lack durability because they too quickly become flattened over a period of use so as to become less tactile or too easily become broken of or torn from the substrate on which they were printed, or both.

Therefore, there is a need for an improved method for industrial printing of tactile markings onto substrates, particularly banknotes.

SUMMARY OF THE INVENTION

A method for making tactile marks, having two-sided tactility, on a substrate, and security documents (e.g. banknotes) made by the method, are provided by the invention. Deposits are printed onto the substrate in a predetermined pattern to form tactile marks adhering to the substrate. A sufficiently high pressure is applied to the substrate with the printed tactile marks to calender the tactile marks, forming corresponding protrusions in the substrate on the opposite sides of the printed tactile marks. The printing material may be an energy curable ink or resin, in which case the method also includes a step of curing the printed deposits. The deposits may be printed by screen printing and the application of pressure to calender the tactile marks may be done by intaglio printing.

An exemplary formulation of the printing material used for an embodiment of the method comprises: (i) about 20-80% by weight of low viscosity monomeric acrylate, having a viscosity below 200 cP at 25 °C; (ii) about 1-30% by weight of urethane acrylate; (iii) about 1-30% by weight reactive diluent; (iv) photoinitiator in an amount sufficient to obtain curing; (v) about 1-10% by weight rheological adsorbing additive; and, (vi) about 2-30% by weight acid acrylate adhesion promoter; wherein the specified weight percentages of components (i)-(iii), (v) and (vi) are relative to a total weight of components (i)-(vi) combined.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are described with reference to the following drawings in which like reference numerals refer to like elements throughout.

Figure 1 is a block diagram showing the steps of an exemplary method for producing tactile marks on banknotes, in accordance with the invention.

Figure 2 is a block diagram illustration of an exemplary screen process for printing tactile marks onto a substrate sheet.

Figure 3 is a profile view of an exemplary tactile mark, in the form of a dot, printed onto a banknote substrate but before a calendering step is applied to the deposited material forming the tactile mark, wherein the dimensions (shape/height) of the deposit and relative dimensions are exaggerated for illustrative purposes only.

Figure 4 is a profile of a banknote to which a printing material (e.g. resin) has been deposited and calendering of the cured deposit, in this example by intaglio printing, has subsequently been performed to apply pressure to the deposit, in accordance with the invention (the dimensions of the deposit and the relief shape are not intended to be accurate but are instead shown in exaggerated form for illustrative purposes only).

DETAILED DESCRIPTION

A method for making two-sided tactile marks has been developed and is claimed herein. Specifically, the invention provides a step of calendering to printed tactile marks on a substrate, by intaglio printing or other printing process which applies a sufficiently high pressure to the tactile marks to create tactile marks having two-sided tactility. The tactile marks are formed from printed deposits of a printing material which is a resin composition in the examples described herein, but may be comprised of another suitable ink, resin or ink-like material having a formulation which is printable to form sufficiently durable tactile marks. Many commercially available printing materials suitable to implement embodiments of the invention are well known to persons skilled in the area of industrial printing and it is to be understood that the invention claimed herein is not limited to any specific printing material.

In the exemplary embodiments described herein the tactile marks are printed onto a banknote substrate sheet, preferably using flat screen or rotary screen printing machines, according to the printing methods which are well known in the printing industry. Referring to Figure 1, this is done by depositing onto substrate sheets 20 a predetermined amount of a curable resin10, for each tactile mark being printed. Once the resin10 has been deposited onto the substrate sheets 20, the resin is cured by exposing it to an energy source such as ultraviolet light (UV) if a UV-curable resin is used. Then, after the resin deposits have been cured to create tactile marks, an intaglio printing step is performed to calender the tactile marks. This calendaring step applies high pressure to the cured deposits to press them into the substrate to form protrusions under the tactile marks (i.e. the cured deposits) i.e. on the opposite side of the substrate to the printed tactile marks. This creates an additional tactile feature, in perfect register, on the opposite side of the substrate whereby the tactile marks become two-sided and, advantageously, provide two-sided tactility to the banknote.

Instead of printing the deposits by screen printing one could use ink-jet printing, using dispenser heads typically used for dispensing of adhesives, such as dispensers manufactured by Pico Dosiertechnik GmbH (Germering, Germany) or pressure-jet printing, using miniature pressure-dispensers, such as liquid dispensing heads available from Fritz Gyger AG Swiss (Gwatt/Thun, Switzerland), both of these printing methods being well known in the printing industry but slow compared to typical high volume security printing equipment. In the examples described herein a UV-curable resin is used, meaning a resin which is cured by exposure to ultraviolet light (UV). Heat curable materials are also known, as well as those which are cured by exposure to a combination of ultraviolet light and heat. In addition, some are curable by an electron beam curing method. In addition to the formulation of the deposited material, the length of exposure of the sheet to the material after deposition, before curing, affects the degree of penetration of the material into the paper, whereby a longer exposure will increase penetration.

In one example of the method, illustrated by Figure 2, a full-scale press test was carried out using both a flat-screen cylinder press as well as a rotary sheet-fed screen press. The flat-screen cylinder press was a SPS Screen Press with SPS Turbostar Conveyer (both from SPS Rehmus, Wuppertal, Germany), operating at 2100 sheets per hour. A curing tunnel was equipped with two UV-mercury lamps, providing a total UV exposure of about 0.8 J/cm^2, as measured using an EIT Power Puck UV-exposure meter (available from EIT Inc., Sterling, VA). The sheet-fed rotary screen press was a Hibis-104 (manufactured by Steinemann Technology AG of Switzerland) operating at a speed of 7300 sheets per hour. The press was equipped with IR and U/V dryers similar to those described above. The marking patterns were made from a variety of mesh screen sizes (approximately 40 to 120) and were circular with diameters of 1 mm. In the result, tactile marks were produced in the form of dots having heights from about 115 to 170 µm. More generally, the resin, when printed onto the substrate sheet at a rate of about 1000-7300 sheets per hour, has a viscosity from 2000-25000 cP at 25 ^{o}C and the deposits are cured by UV light exposure of about 0.2-3 J/cm^2. Although in this example the tactile marks formed dots, resembling Braille characters, it will be understood by the reader that many other printing options can be used to produce other forms of tactile marks, as desired, for a given application. For example, other shapes, such as bars, ovals, stars or triangles may be used. Further, they may be applied in such a manner as to provide secondary tactile structure, such as humps or valleys, if desired for a particular application.

A UV material specially developed by the assignee of this invention was used for testing of this invention but other known resins and ink-like materials used for printing tactile marks may be used. The UV material used for the examples described herein was developed by the assignee to provide improved properties of resilience, flexibility, adherence and durability compared to conventional screen resins. This specially developed material has a composition which includes a low viscosity monomeric acrylate having a viscosity below 200 cP at 25 °C, in an amount of about 20-80% by weight, a urethane acrylate in an amount of about 1-30% by weight and a reactive diluent in an amount of about 1-30% by weight. A photoinitiator is included, sufficient to obtain curing, and a rheological adsorbing additive in an amount of 1-10%. An acid acrylate adhesion promoter, in an amount of 2-30% by weight, is also included and, optimally, this component is added after the acrylate components have been at least partly adsorbed on the rheological additive.

Specific examples of the formulations of the assignee's specially developed deposit material used to make embodiments of this invention are provided in the following. As a low viscosity acrylate, an acrylic monomer was selected from neopentyl glycol diacrylate (e.g. SR 247 sold by Sartomer or Photomer 4127 sold by Cognis), tetrahydrofurfuryl acrylate (e.g. SR 285 sold by Sartomer), tetrahydrofurfuryl methacrylate (e.g. SR 203 sold by Sartomer), stearyl acrylate (e.g. SR 257 sold by Sartomer) and dipropylene glycol diacrylate (e.g. SR508 sold by Sartomer). The urethane acrylate of these exemples is an aliphatic polyester urethane acrylate. The reactive diluent component used is tri-functional (SR-9020HP™ by Sartomer) and the rheological additive is fumed silica gel (e.g. Aerosil-200™ available from Evonik Degussa) or precipitated silica (e.g. Silica Gel, Grade 9382, 230-400 mesh, available from Sigma-Aldrich, St. Louis, MO, U.S.A.). The adhesion promoter used is a tri-functional acid ester (Sartomer – CD-9053™). One such exemplary formulation, provided by way of illustration only, is the following:

Component	**Wt. %**
Cognis - Photomer 4127™	50.57
Sartomer – CN-9009™	20.44
Sartomer – SR-9020HP™	8.53

Lamberti – Esacure KS 300™	3.1
Lamberti – Esacure TZT™	2.17
Aerosil 200	3.12

By post-addition, Sartomer – CD-9053™ 12.07

The paper-penetration parameter of the exemplary material of the tactile marks is controlled by means of the concentration of the low viscosity component in the formulation and by screen press parameters, such as specific screen mesh size, number of emulsion layers, the heating of the deposited material before UV curing and the linear velocity of the conveyer belt. An increase in the concentration of the low viscosity component, heating the deposited material before UV curing and slowing down the velocity of the conveyer may be employed to cause the penetration of the material by the substrate to become more effective.

After the substrate has been printed with tactile marks as described and the printed tactile marks have been cured, an advantageous new step of pressure treatment of the cured tactile markings, referred to as calendering, is performed. In the illustrated examples this is done by means of an intaglio printing step. This calendering step, applied to the tactile marks, serves to, in effect, re-position the tactile markings in the banknote in such a manner as to form protrusions under the tactile markings, thereby producing a banknote having two-sided tactility in perfect register. In this additional step, the tactile marks are partly pressed into the substrate by high pressure intaglio calendering, which is a process that is well known in the printing industry. Surprisingly, it was found that the very high pressure exerted onto the tactile marks by the intaglio calendering step does not significantly reduce the height of the screen-printed tactile marks. Even more surprisingly, it was found that the high-pressure pressing of the tactile marks against a flat plate, during the intaglio printing step, results in significant tactility being created on the side 40 of the substrate, opposite the side on which the material of the tactile marks was deposited, as shown in Figure 4.

Before the application of high pressure through the calendering step, the cured material of the tactile mark10 (see Figure 3) adheres to the flat substrate sheet 20. As a result of the intaglio printing application of high pressure in this example, the compressed ink 10 is pressed into the sheet 20 (see Figure 4) such that a protrusion is formed in the substrate sheet on the opposite side 40 of the compressed material of the tactile mark and this provides an additional, significant tactile effect on that underside surface of the tactile mark which complements the effect of the tactile mark itself.

For the intaglio calendering step of the exemplary, illustrated embodiment, banknote substrate sheets are passed through an intaglio press manufactured by KBA-Giori, Lausanne, Switzerland. In the printing of banknotes, intaglio printing is conventionally applied to various parts of the banknotes, and this tactile mark processing may be advantageously combined with the normal intaglio printing step directed to other parts of the banknotes. To do so, the intaglio press plate area corresponding to the tactile marks is not inked. Instead, in this area, the intaglio calendering pressure is used to achieve protrusion of the tactile marks to the back side of the sheets (not specifically shown in the drawings). Other areas of the intaglio plate are inked as in conventional production for a banknote. Thus, the conventional intaglio printing process proceeds normally in those other areas of the banknotes, while the calendering pressure treatment is applied to the tactile marks, causing them to partly protrude to the back side of the banknote substrate. As a result, significant relief shaped marks are produced on the back side of the substrate sheets, directly under the tactile marks. Since the protrusion of the tactile marks remains on the front side of the substrate sheets, the tactility can be sensed, by feel, on both sides of the banknote paper in a face to back perfect register (the term "perfect register" being commonly used in the printing industry and understood by persons skilled in the area of industrial printing). This is advantageous because people with impaired vision can sense tactility better using two fingers (i.e. passing over opposite sides of a banknote) rather than with one finger, as the case would be without high pressure embossing of the tactile dots. In the example described herein, the intaglio compression caused loss of only about 20 μm of tactile mark height. In this example, on a sheet where the average height of the marks before compression was 170 μm, after compression the average total height of the marks was still 150 μm.

The banknote printed tactile marks produced according to the foregoing demonstrate significantly improved durability for the expected period of use of the banknote. Physical resistance tests were performed on the banknote printed UV-cured tactile marks by subjecting them to crumple, tumbling and abrasion tests. Chemical resistance tests were also performed whereby tactile marks deposited onto paper and polymer substrates were immersed in organic solvents, acids and bases.

In particular, a crumpling procedure commonly used in the banknote printing industry was performed using an IGT Crumple Tester (from Research North America, Cherry Hill, NJ). Tactile marks deposited onto paper substrate were crumpled 8 times, while the dots deposited onto a polymer substrate were crumpled 24 times. In both cases, the tactile marks remained on the substrate after the crumpling was finished. That crumpling test is used effectively for banknotes and is considered to be harsher than several years of circulation of a banknote. Other durability tests carried out on the dots were tumbling tests. The tumbling tests were carried out using a rubber-lined lapidary tumbler filled with 24 zirconium oxide balls, each weighing 31.5 grams. A 4" x 4" cloth wetted with 5 grams of artificial sweat was also placed inside of the tumbler. The tumbling test was carried out for two hours at room temperature and all of the tested tactile marks survived this test.

Abrasion tests were also carried out using a Taber Abraser, Model 503 (Taber Instrument Company, North Tonawanda, NY), with S-10 abrasive wheels loaded with 250 grams of weight for testing of tactile marks on a paper substrate, and 500 grams for tactile marks deposited on a polymer substrate. Two tests were done for each substrate: one with 100 rotations and one with 400 rotations of the abrasive wheels. The tactile marks survived the abrasive actions and retained an acceptable level of tactility after 400 rotations.

Chemical resistance tests performed on the tactile marks also showed them to be durable. The tactile marks survived a 30 minute exposure (at room temperature) to each of methanol, ethanol, tetrachloroethylene toluene and heptane, without noticeable damage.

The durable, easily recognizable and easy-to-feel tactility of the UV-cured tactile marks produced according to the foregoing description can assist visually impaired people in validating security documents by incorporating the tactile marks into those security documents.

Exemplary embodiments have been disclosed by the foregoing and are to be considered as illustrative only, not restrictive or limiting of the scope of the invention. It is to be understood by the reader that various changes and modifications can be made while still making use of the invention, which is defined by the appended claims, and without departing from the scope thereof. All variations and equivalents coming within the meaning of the appended claims are intended to be embraced within the scope of the present invention.

WHAT IS CLAIMED IS:

1. A method for making tactile marks, having two-sided tactility, on a substrate, comprising the steps:

(a) printing deposits onto the substrate in a predetermined pattern to form tactile marks adhering to the substrate; and,

(b) applying to the substrate with the printed tactile marks a sufficiently high pressure to calender the tactile marks, forming corresponding protrusions in the substrate on the opposite sides of the printed tactile marks.

2. A method according to claim 1 whereby an energy curable printing material is used to print the deposits, and further including a step of curing the printed deposits.

3. A method according to claim 2 whereby the step of applying pressure to calender the tactile marks is by intaglio printing.

4. A method according to claim 2 whereby deposits are printed by screen printing.

5. A method according to claim 3 whereby the energy curable printing material is ink or resin.

6. A method according to claim 3 whereby the printing material comprises: (i) about 20-80% by weight of low viscosity monomeric acrylate, having a viscosity below 200 cP at 25 ^{o}C; (ii) about 1-30% by weight of urethane acrylate; (iii) about 1-30% by weight reactive diluent; (iv) photoinitiator in an amount sufficient to obtain curing; (v) about 1-10% by weight rheological adsorbing additive; and, (vi) about 2-30% by weight acid acrylate adhesion

promoter; wherein the specified weight percentages of components (i)-(iii), (v) and (vi) are relative to a total weight of components (i)-(vi) combined.

7. A security document comprising tactile marks made by the method of any one of claims 1 through 6.

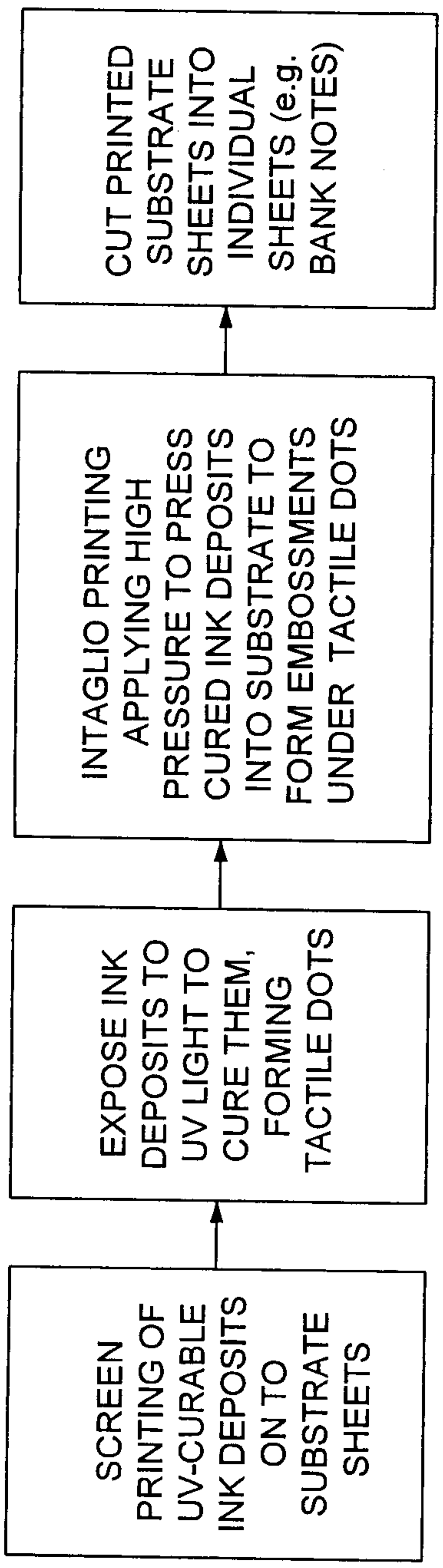
SCREEN PRINTING OF UV-CURABLE INK DEPOSITS ON TO SUBSTRATE SHEETS
EXPOSE INK DEPOSITS TO UV LIGHT TO CURE THEM, FORMING TACTILE DOTS
INTAGLIO PRINTING APPLYING HIGH PRESSURE TO PRESS CURED INK DEPOSITS INTO SUBSTRATE TO FORM EMBOSSMENTS UNDER TACTILE DOTS
CUT PRINTED SUBSTRATE SHEETS INTO INDIVIDUAL SHEETS (e.g. BANK NOTES)

FIG. 1

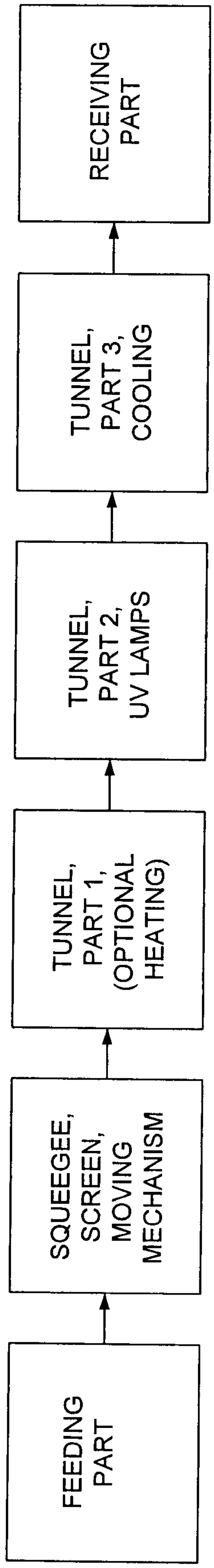
FEEDING PART
SQUEEGEE, SCREEN, MOVING MECHANISM
TUNNEL, PART 1, (OPTIONAL HEATING)
TUNNEL, PART 2, UV LAMPS
TUNNEL, PART 3, COOLING
RECEIVING PART

FIG. 2

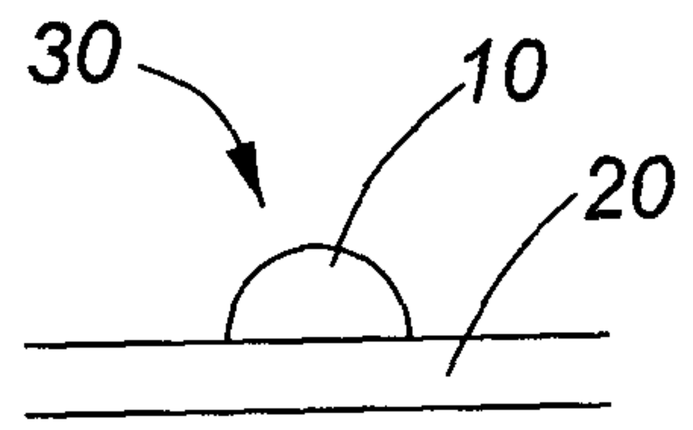

FIG. 3

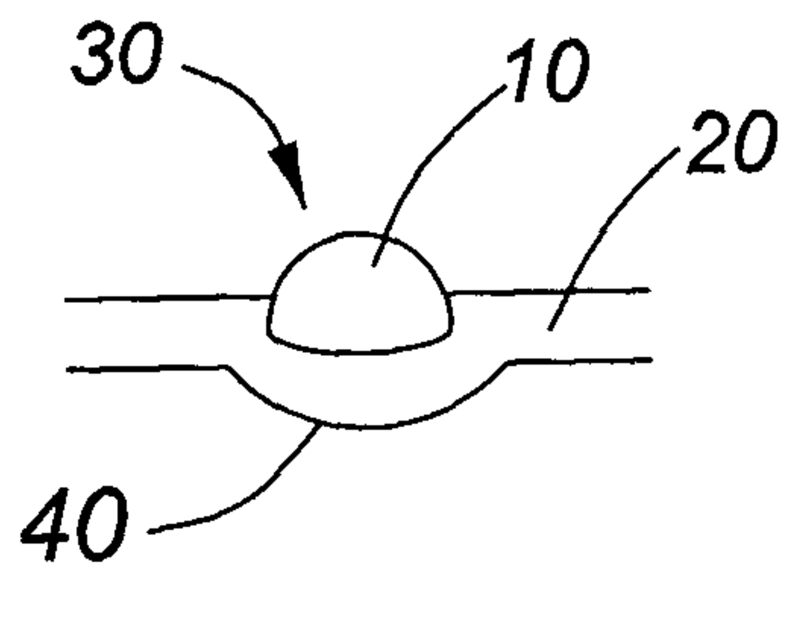

FIG. 4

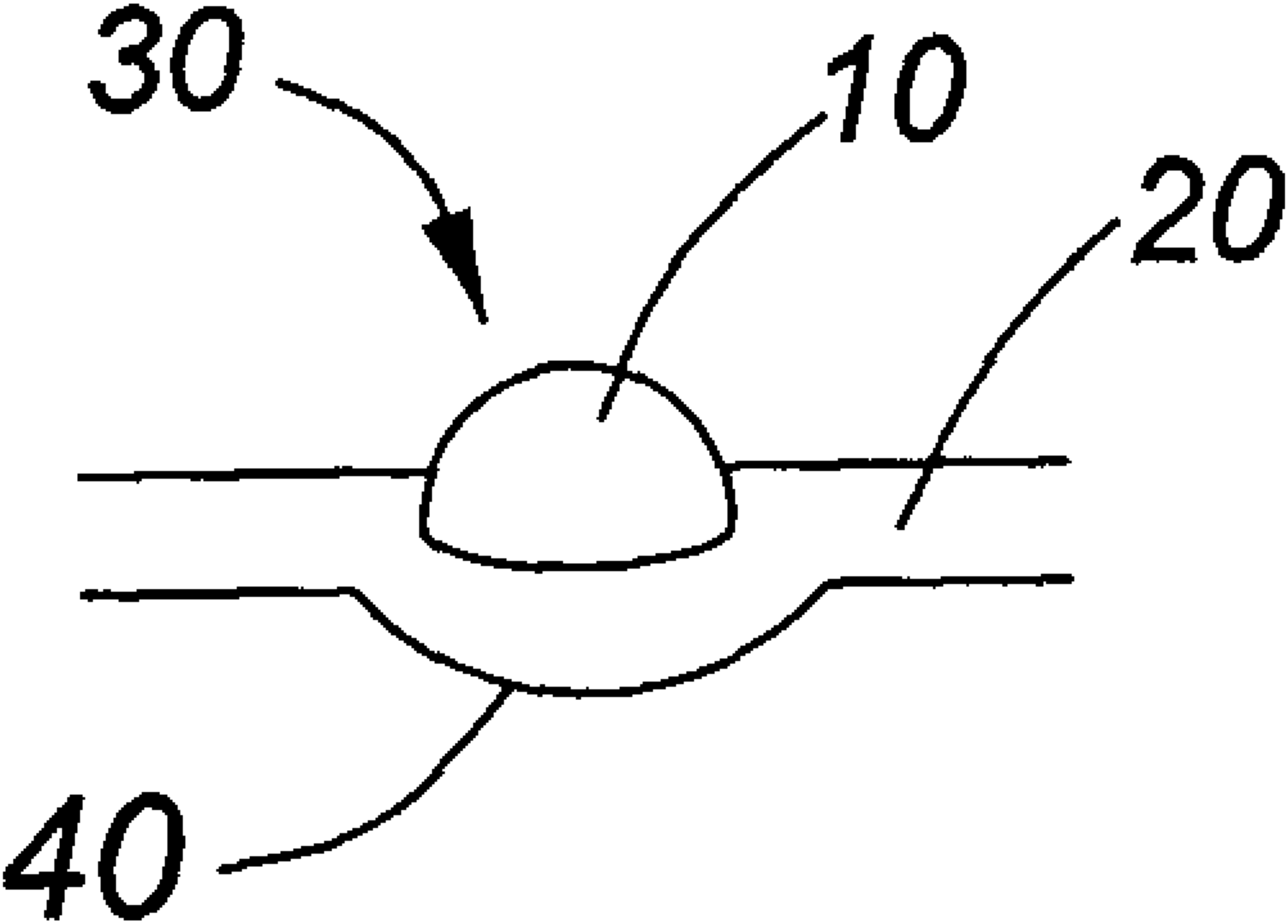

FIG. 4