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**Screen-printing process.**

A process for the preparation of printing screens comprises the steps of: a) - defining a negative pattern for printing a color component of a multicolor printing process and registering the same as a computer file; b) applying a flowable, hardenable screen glue onto a screen substrate in droplet form, while controlling the application of said substance by computer means according to said computer file to produce said negative pattern on said screen substrate; and c) - allowing or causing said screen glue to harden to produce a screen consisting of said screen substrate carrying said negative pattern.

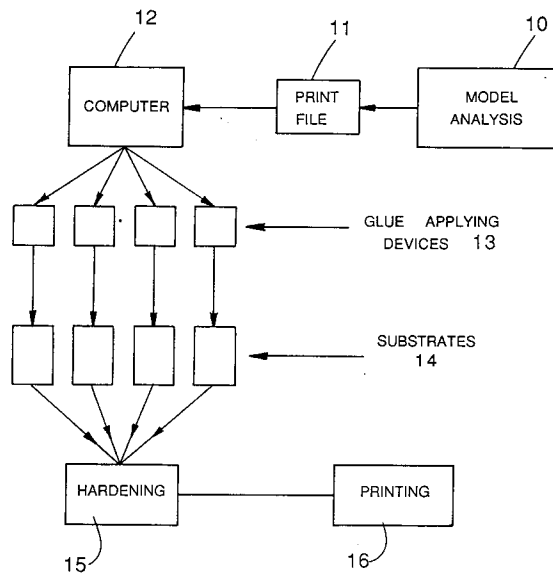


Fig. 1

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### Field of the Invention

This invention relates to a screen-printing process for printing designs in different colors, usually in four colors, on sheet-like backings such as textile fabrics, paper, plastic sheets and the like, to the screens obtained by said process, and to an apparatus for carrying out said process.

### Background of the Invention

Multicolor screen-printing is currently carried out by means of masks prepared by photographic processes. A mask is prepared for each color, the substrate of which is a silk or gauze sheet, the pores of which are blocked where it is not wished that the color should pass. In order to define the shape of the mask, viz. the distribution of the pores that must be occluded, which constitute what may be called the negative printing pattern, a photographic process is used. A light sensitive gelatine-like material is spread on the silk or gauze backing to form a continuous film. The film is exposed to light to precipitate insoluble material at the appropriate places, and is thereafter dissolved at all other places, as it is done in conventional photographic processes, to produce a negative pattern. The accuracy of the photographic process affords satisfactory registering of the masks for the various colors, to obtain a multicolor, e.g. a four-color print, of good quality.

The prior art process is, however, multiphase and therefore rather complex. It is also expensive because of its complexity and of the materials used. Furthermore, the screens used for a printing cannot be re-used. Finally, there is room for improvement even in the quality of the printing thus obtained.

It is a purpose of this invention to provide a process for the preparation of color printing screens and a screen-printing process which are simple and economical, and permit to obtain the multicolor, e.g. four-color printing screens and printed articles, of the highest accuracy and quality.

It is another purpose of the invention to provide a process for the preparation of color printing screens which consists essentially of a single phase.

It is another purpose of the invention to provide such a process whereby the screens can be easily re-used for different printings.

It is a further purpose of the invention to provide such a process which uses economical raw materials.

It is a still further purpose to provide such a process which can be carried out by readily available and efficient apparatus.

It is a still further purpose to provide such a process which permits to create the greatest variety of patterns and fineness of printing detail.

It is a still further purpose of the invention to provide an efficient and relatively inexpensive apparatus for carrying out the process according to the invention.

It is a still further purpose of the invention to provide efficient, inexpensive and re-usable printing screens.

Other advantages and purposes of the invention will be apparent as the description proceeds.

### Summary of the Invention

The process for the preparation of printing screens according to the invention is characterized in that it comprises the steps of:

- a) - defining a negative pattern for printing a color component of a multicolor printing process and registering the same as a computer file;
- b) applying a flowable, preferably liquid, hardenable substance (hereinafter called "screen glue") onto a screen substrate, such as a silk or gauze sheet, in droplet form, while controlling the application of said substance by computer means according to said computer file to produce said negative pattern on said screen substrate; and
- c) - allowing or causing said screen glue to harden to produce a screen consisting of said screen substrate carrying said negative pattern.

The screen printing process according to the invention comprises the additional step of

- d) - applying to the material to be printed (hereinafter "print substrate") through said screen a color composition having the appropriate color, said composition being free of any solvent or softener of said screen glue.

Operations a) to c) are repeated to produce a different screen for each color component of said multicolor-color printing process and operation d) is repeated for each color component in mutually registered relationship.

Preferably, the screen glue is applied to the screen substrate by ejecting it in the form of drops from an orifice, and preferably said ejection is carried out according to the ink-jet process or the bubble-jet process, or equivalent processes known in the art.

The printing process will often be the four-color process, viz. the aforesaid operation a) to d) will be repeated four times on different screens. However, it is possible to employ less, e.g. two, colors, or to add additional colors, i.e., the so-called fifth, sixth, etc. colors, e.g., a gold or silver color.

The pattern according to which the screen glue is applied to the screen substrate, viz. the "nega-

tive pattern", is defined by a program which controls computer means which in turn control the apparatus for ejecting the screen glue in drop form, e.g. the ink-jet or bubble-jet apparatus.

The hardening of the screen glue will preferably be obtained by applying said glue in solution or suspension form or other flowable form, and then drying the solution or suspension or allowing it to dry. By "flowable" is meant herein any physical state in which the glue can flow through and be ejected from a droplet forming apparatus. Swellable polymers, e.g., may be compounded with a thinner and become gradually more flowable and increasingly less viscous, until they can be processed by an ink- or bubble-jet or like device. Such substances do not exhibit a sharp transition between the solid, dry state and the dissolved, liquid state, but exhibit increasing degrees of plasticity from an apparently solid to an apparently liquid state. They can be used in carrying out the invention, provided only that they can be processed by ink- or bubble-jet or like devices. In a less preferred form of the invention, the screen glue could be a substance that can polymerise and/or crosslink, and its hardening could be brought about by polymerisation and/or crosslinking, activated by chemical means, or by the application of heat, or by photocatalysis, or by any polymerization and/or crosslinking processes known in the art.

When the screen glue is applied in the form of a solution or a suspension or other flowable form, the solvent or suspension or thinning medium will be different from and incompatible with the solvent or diluting medium which is part of the color composition, by which is meant that this latter will not be such as to dissolve or significantly swell or soften the screen glue. E.g., if the color composition is an aqueous suspension of a pigment, the screen glue will be insoluble in water and will be applied in a solution or suspension in an organic solvent immiscible with water. *Vice versa*, if the color composition liquid base is a water-immiscible organic solvent, the screen glue will be applied in solution or suspension in a liquid medium that is either water or another organic solvent immiscible with said base.

If the screen glue is a solution or a suspension, the dissolved or suspended solid material may be any convenient material, in particular a polymeric material. The polymeric material may be either a natural polymer or a derivative thereof, such as, e.g., carboxymethylcellulose, or any other such product used as a sizing in the textile industry, or it may be a synthetic polymer. Synthetic polymers may be soluble in hydroxylated solvents, which may include water, as in the case of polyvinyl alcohol, or may be polymers such as polyvinyl chloride or acrylic polymers, which are only soluble

in organic solvents. Thus, the liquid medium of the screen glue may consist of or contain halogenated organic solvents or mixtures thereof with other solvents such as carbon sulfide, or in the case of acrylic polymers, aprotic solvents such as dimethylformamide, dimethylacetamide, and the like.

Once the printing has been completed, the screen substrate may be recovered and re-used by dissolving the screen glue with an appropriate solvent.

The correspondence of the various negative patterns relating to the different printing colors is assured by the computer means, programmed according to a program which is obtained by analyzing a colored print model according to processes that are well known in the printing art. Thus, the chromatic analysis of the colored print model may be considered as a preliminary step of the process according to the application, although such a step will not be described hereinafter, because it is well known, as has been said, in the printing art.

The advantage of the invention can be further evidenced by comparing it, e.g., with processes involving color separation, in which a plurality of screens is prepared and much hard work is involved.

The application of the color compositions to the print substrate through the screens may be carried out as in prior art screen printing and therefore need not be described.

The apparatus for preparing printing screens according to the invention comprises means for applying screen glue in drop form to a screen substrate, such as an ink-jet or a bubble-jet apparatus, computing means for controlling the screen glue applying means according to a printing program, and mechanical means for producing relative traversing and advancing motions between the screen substrate and the screen glue applying means, to produce a screen consisting of the screen substrate carrying the desired negative pattern.

In order to effect a complete screen-printing process, said apparatus is further combined or coordinated with means, conventional *per se*, for successively applying the desired color compositions to a print substrate through the printing screens. Such means can be provided in the same or in a separate apparatus.

Optionally, means may be provided for causing or facilitating the hardening of the screen glue and/or means for scanning a color print original to produce print programs for the desired colors.

Further, means are provided, which may be conventional *per se*, for assuring the registration of the different color patterns when applying the color compositions through the screens to the print sub-

strate.

A screen according to the invention comprises a screen substrate, of silk, gauze or the like, and a negative pattern of a hardened screen glue that is insoluble in the color composition to be used for printing with said screen and is preferably soluble in a screen glue solvent.

### Description of the Drawings

In the drawings:

- Fig. 1 is a block diagram illustrating the various phases of the process according to an embodiment of the invention;
- Fig. 2 is a schematic lateral side view of an apparatus for preparing a screen according to an embodiment of the invention; and
- Fig. 3 is a plan view from the top of the same.

### Detailed Description of Preferred Embodiments

With reference to Fig. 1, the phases of the process according to the invention are the following. A color print model is analyzed (block 10) and the color patterns relating to the basic color components, e.g. the four basic components, are registered in a computer file (block 11). Said computer file controls the operation of a computer 12. The computer 12 in turn controls the operation of the screen glue applying devices, e.g. ink-jet or bubble-jet devices, 13. In this embodiment four such devices are shown, since it is assumed that a four-color printing is carried out. The negative patterns according to the various colors are created on different screen substrates (block 14). The screen substrates carrying the negative patterns that are still in liquid form are subjected to the hardening process (block 15), either by mere evaporation or by heating or by other means, such as polymerizing and/or crosslinking means. Finally, the appropriate colors are applied to the print substrates in succession (block 16) by means of the corresponding screens, in mutually registered relationship.

The apparatus for carrying out the invention is schematically illustrated in Figs. 2 and 3. The screen substrate 20 is attached to a frame 24, supported by structure generally indicated at 21. The screen glue applying device 22, controlled by a computer 23, is moved, by means not shown, transversely across the screen substrate, in alternating traversing motion from side to side. In each traversing motion the device 22 covers a transverse strip of the screen substrate having a certain width or thickness "p", which can be called the "pitch" of the negative screen pattern formation, viz. applies the screen glue liquid composition that is required for such a strip at the required

points thereof. The volume of the droplets ejected by the device 22 will be adapted to produce a strip of the width "p". After each traversing motion, the device 22 advances lengthwise of the screen substrate by a distance that is equal to the said negative pattern formation pitch "p". The advancing means are also not shown, as they may be quite conventional. Alternatively, the device 22 could carry out the traversing motion only, and the screen substrate could be advanced by the width of the aforesaid strips after each traversing motion of the device 22.

The screen substrate, instead of being formed in individual pieces, could be continuous and continuously fed from a roll and then cut into individual screens of the desired length, optionally after having been dried and optionally wound up in a roll. The hardening operation can be carried out in any desired way, e.g. merely by allowing the screen to stand for some time or by heating it or by any other means easily devised by persons skilled in the art.

Of course, the process according to the invention could be carried out on screen substrates that are not flat, for instance are in cylinder form, and this would merely involve substituting a rotation of a cylindrical screen substrate for the advancing motion of the flat screen substrate. All these variations will be obvious to persons skilled in the art, and can easily be carried out by them. In general, apparatus for applying liquid or flowable substances to textile, paper or plastic substrates are well known in the art and can be used according to their suitability to any individual embodiment of this invention.

The apparatus for applying the colors in succession and registered relationship to the print substrate is not illustrated as it can be conventional and need not be different from similar apparatus used in conjunction with prior art screen-printing methods.

Convenient materials for the screen glue composition, with reference to the color compositions used, are compositions in organic solvents or based on water, which are used to produce reusable screens. Glues based on epoxy resins, on the other hand, are not reusable as the glue cannot be removed. Glues adapted to specific requirements (drying time, removability, etc.) can be selected by the skilled engineer, e.g., also from ink-jet or other inks commonly available on the market.

Screens will normally be selected from polyester, nylon or metal (e.g., nickel) screens. Accordingly, a great variety of materials, glues, screens, ink or bubble-jet devices, etc., can be used, all without exceeding the scope of the invention.

## Claims

1. Process for the preparation of printing screens characterized in that it comprises the steps of:
  - a) - defining a negative pattern for printing a color component of a multicolor printing process and registering the same as a computer file; 5
  - b) applying a flowable, hardenable screen glue onto a screen substrate in droplet form, while controlling the application of said substance by computer means according to said computer file to produce said negative pattern on said screen substrate; and 10
  - c) - allowing or causing said screen glue to harden to produce a screen consisting of said screen substrate carrying said negative pattern. 15
2. Screen printing process comprising preparing a printing screen according to claim 1 and comprising the additional step of
  - d) - applying to the print substrate through the screen a color composition having the appropriate color, said composition being free of any solvent or softener of said screen glue. 20
3. Screen printing process according to claim 2, comprising repeating operations a) to c) to produce a different screen for each color component of said multicolor-color printing process and repeating operation d) for each color component in mutually registered relationship. 25
4. Printing screen preparation process according to claim 1, wherein the screen glue is applied to the screen substrate by ejecting it in the form of drops from an orifice. 30
5. Printing screen preparation process according to claim 4, wherein the screen glue is ejected in the form of drops formed with the ink-jet or the bubble-jet process. 35
6. Printing screen preparation process according to claim 1, wherein the screen glue is applied to the screen substrate according to a pattern defined by a program which controls computer means which in turn control the apparatus for ejecting the screen glue in drop form. 40
7. Printing screen preparation process according to claim 1, wherein the hardening of the screen glue is obtained by applying said glue in solution or suspension form, and then drying the solution or suspension or allowing it to dry. 45
8. Printing screen preparation process according to claim 7, wherein the solvent or suspension medium of the screen glue solution or suspension is different from and incompatible with the solvent or diluting medium which is part of the color composition. 50
9. Printing screen preparation process according to claim 8, wherein the screen glue is a polymeric material and is applied in a solution or suspension in an organic solvent. 55
10. Printing screen preparation process according to claim 8, wherein the screen glue is chosen from among cellulose derivatives and polyvinyl or acrylic polymers.
11. Printing screen preparation process according to claim 8, wherein, once the printing has been completed, the screen substrate is recovered and re-used by dissolving the screen glue with an appropriate solvent.
12. Apparatus for the preparation of printing screens, characterized in that it comprises means for applying screen glue in drop form to a screen substrate, computing means for controlling the screen glue applying means according to a printing program, and mechanical means for producing relative traversing and advancing motions between the screen substrate and the screen glue applying means, to produce a screen consisting of the screen substrate carrying the desired negative pattern.
13. Apparatus according to claim 12, wherein the means for applying screen glue in drop form to the screen substrate comprises an ink-jet or a bubble-jet apparatus.
14. Apparatus according to claim 12, furthers comprising means for causing or facilitating the hardening of the screen glue.
15. Apparatus according to claim 12, further comprising means for scanning a color print original to produce print programs for the desired colors.
16. Printing screen comprising a screen substrate and a negative pattern of a hardened screen glue that is insoluble in the color composition to be used for printing with said screen.
17. Printing screen according to claim 16, wherein the screen glue is soluble in a screen glue solvent.

18. Printing screen according to claim 16, wherein the screen substrate is a porous structure of silk, gauze or the like.

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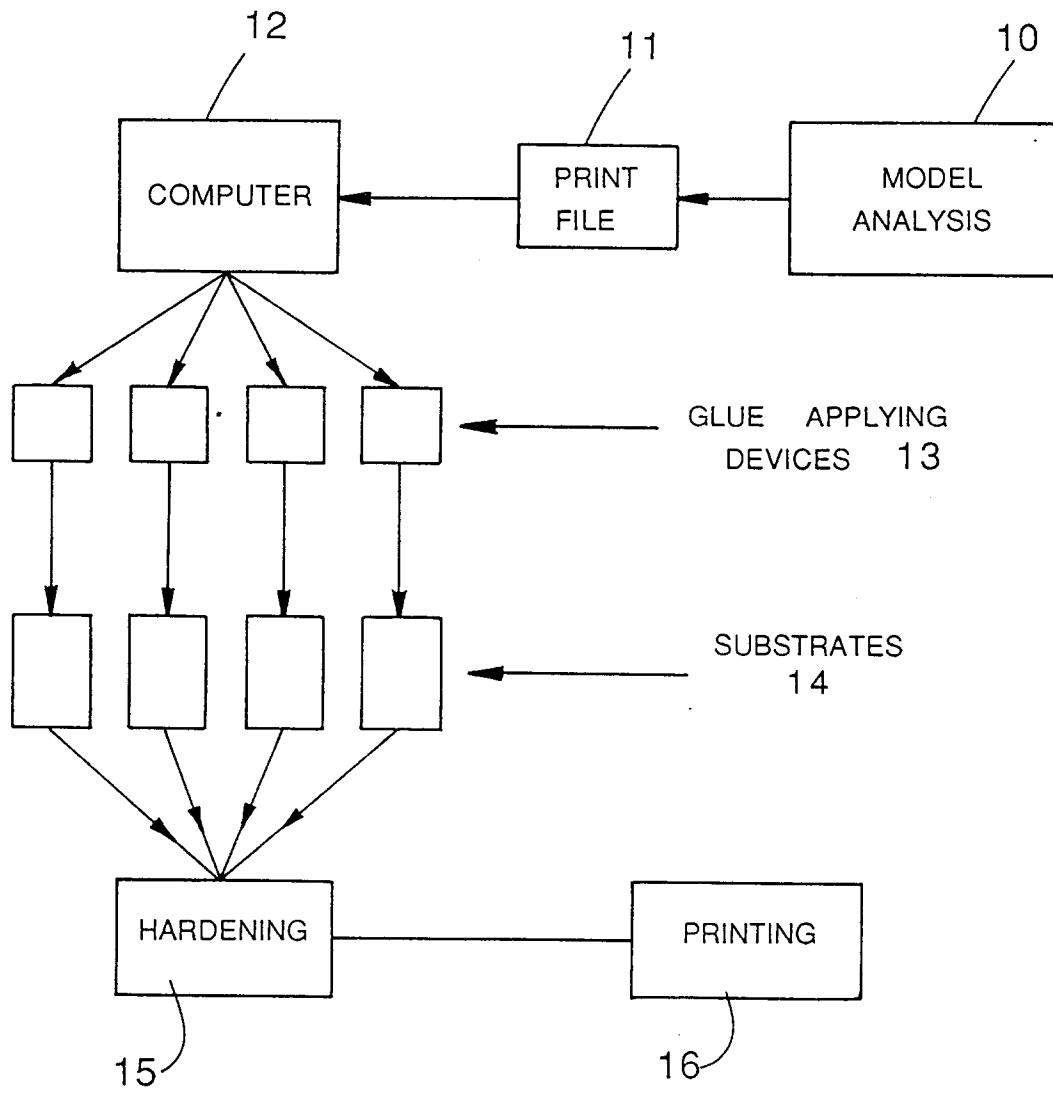
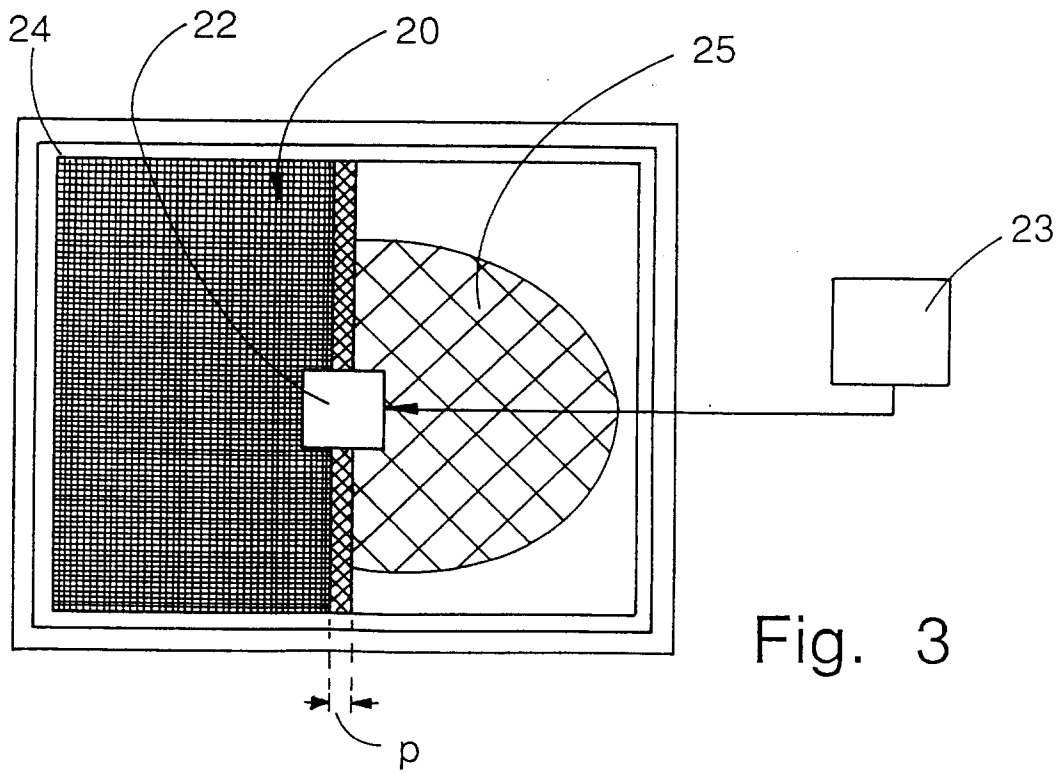
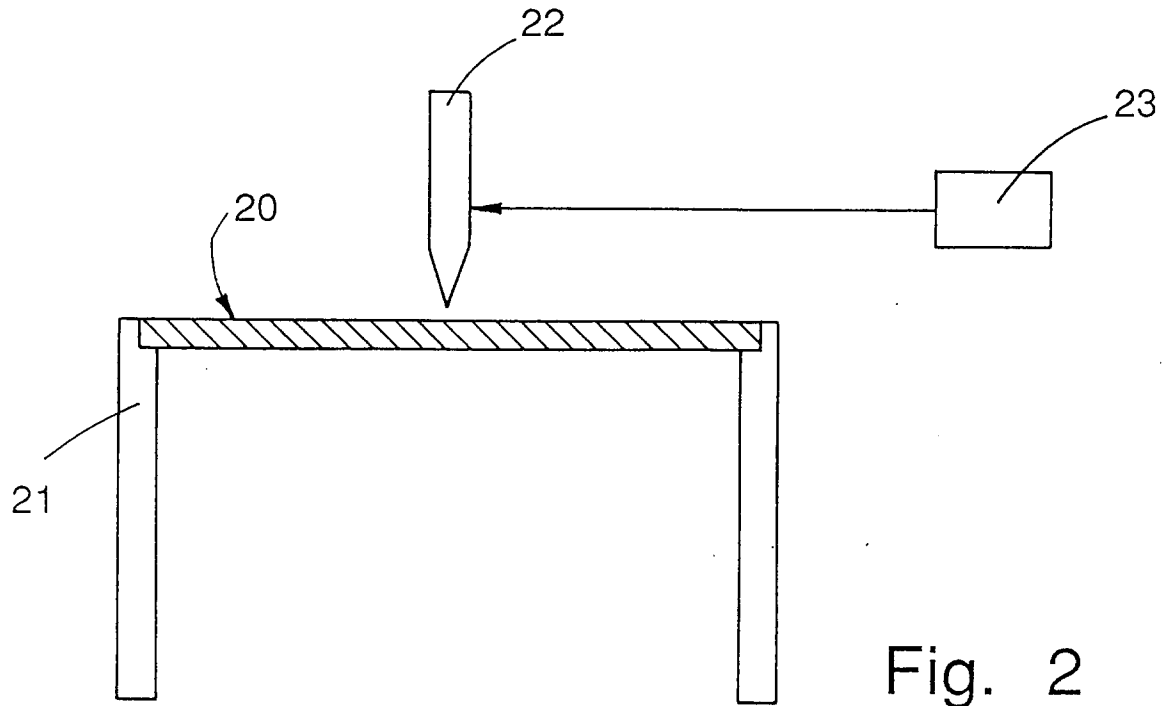


Fig. 1







DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	US-A-5 072 671 (M.A.N.-ROLAND DRUCKMASCHINEN AG) * column 17, line 19 - column 18, line 15; figures 17,18 *	1-18	B41C1/14
Y	EP-A-0 101 266 (MILLIKEN RESEARCH CORPORATION) * page 28, line 18 - page 29, line 3 * * page 61, line 9 - line 15; claims 7,12; figures 9-12 *	1-18	
A	EP-A-0 492 351 (GERBER SCIENTIFIC PRODUCTS, INC.) * column 3, line 38 - column 6, line 17; figures 1,2 *	12-15	
A	GB-A-1 030 367 (WILKS R.V.) * the whole document *	7-10, 16-18	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			B41C B41N
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 November 1993	Examiner THIBAUT, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			