PATENT SPECIFICATION (11) 1 591 488

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(21) Application No. 21762/78 (22) Filed 24 May 1978 (19)

(31) Convention Application No. 52/059395 (32) Filed 24 May 1977 in

(33) Japan (JP)

(44) Complete Specification Published 24 Jun. 1981

(51) INT. CL.[3] C25D 1/08

(52) Index at Acceptance
C7B 113 120 301 305 325 727 744 EC



(54) PLATING PROCESS FOR PRODUCING SCREENS

(71) We, KABUSHIKI KAISHA KENSEIDO, of 45-7, Miyamotocho, Itabashiku, Tokyo, Japan, a body corporate of Japan, and TOPPAN PRINTING CO. LTD., of 5-1, Taito 1-chome, Taitohku, Tokyo, Japan, a body corporate of Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to a plating process for producing screens. The present process can be used for producing rotary screens i.e. sleeves, and flat screens, and in particular can be used for half tone screens containing images.

A conventional method for producing a sleeve for rotary screen printing will first be described. This method is as illustrated in Figures 1 and 2 of the drawings which are cross-sections of the conventional sleeve during stages in its production. A master roll A has projections and recesses on its surface and has a non-electrically-conductive resin 2 embedded therein.The master roll A is of metal 1 and a metal plating 3 is deposited on the exposed parts of the metal 1 of the master roll A by a plating treatment in a plating bath. In this way, as can be seen from Figure 1, the metal plating 3 comes to coat areas of the non-electrically-conductive resin 2. It will be appreciated that as the thickness of the metal plating 3 increases so the coated area of the resin increases. In the case of the product shown in Figure 2, the thickness "b" of the metal plating 3 is almost the same as the width "a" of the lateral widening to coat the non-electrically-conductive resin. The conventional method thus has the drawback that the width "c" of the openings in the sleeve becomes small.

The present invention seeks to provide a plating process for producing rotary or flat screens, especially screens for printing, with a high opening ratio, that is a high ratio for the area of the openings of the screen relative to the total area of the screen.

In order to inhibit the lateral widening of the metal plating the inventor of the present invention has previously employed a method which is illustrated by Figures 3 and 4 of the accompanying drawings. In this method a non-electrically-conductive resin is employed to fill the holes in a partially-plated screen and then plating is repeated to build up the metal plating to the required thickness. Figure 3-1 shows an intermediary stage in which a large amount of resin 4 has been used to fill the holes and polishing with sandpaper has then been employed to remove excess dried resin in order to expose projecting parts of the metal plating 3. Figure 3-2 illustrates a corresponding intermediary stage in which a small amount of resin 4 is applied. In either case it is found that, as shown in Figure 4, the top of the projecting part of the metal plating 3 is shaved off by the polishing treatment, and that as a result the surface e is roughened and at the same time uneven polished parts d are formed on side portions of the surface. It is then found that when the plating is repeated a terminal current is formed at the uneven parts d and plating occurs faster at d resulting in enhancement of the uneveness and reduction in the opening ratio.

According to the present invention we provide a plating process for producing screens which comprises:

(a) plating a prepared master roll or plate with a metal plating;

(b) applying a non-electrically-conductive resin on to the plating;

(c) while the resin is still undried or uncured, using a material compatable with the resin to remove the resin applied to projecting areas of the metal plating and thereby expose the projecting areas; and

(a') plating metal on the projecting areas;

the series of steps (b), (c) and (a') being carried out one or more times to build up the thickness of the metal plating to a required thickness.

By contacting the applied resin with a non-metallic roll or plate receptive to the resin it is possible to remove the resin from the projecting areas of the partially built-up metal plating without deleteriously affecting the plated metal and with the result that repetition of the steps (b), (c) and (a') can produce a screen with a high opening ratio.

The present process can be used for rotary or cylindrical screens or for flat screens and moreover in the case of image-containing halftone screens it is possible to produce a screen faithfull to the original image at a cheap cost and with certainty. The commercial value of the present process is thus expected to be high.

The preparation of the master roll or plate can be conventional and will typically involve forming non-electrically-conductive areas by embedding resin such as thermosetting epoxy resin in its surface or by shaping a photosensitive resin membrane. In particular, the following methods can be used for preparing the master roll or plate:

In a lacquer process, copper plating is applied onto a metal roll or plate made for example of iron and the finished surface of the copper plating is polished with a polishing machine. Then by using a mill roll (matrix form) which has been tempered to a high hardness, and also a pushing machine, the polished surface of the copper plating is engraved. The resultant engraved surface is subjected to chromium plating or hard nickel plating and then recesses of the surface corresponding to engravings in the original are filled with a non-electrically-conductive resin such as a thermosetting epoxy resin. This then gives the master roll or plate.

In a Galvano process, copper plating is applied onto an iron roll, after polishing by a polishing machine, chromium plating or hard nickel plating is applied to give a finished roll or plate. A stainless steel roll or plate is polished and thus a Galvano master roll or plate is obtained. On the resulting finished roll, a layer of photosensitive resin membrane is formed by a spraying process or a ring coating process or the like in case of liquid state or by pressure-adhesion carried out under heating in case of film state. Then a negative image film containing penetrating type mesh is contacted and said film surface is exposed to light by using a xenon lamp, a ultraviolet lamp, etc. After the layer of the resin membrane of the exposed portions is cured, the layer of the resin membrane of the unexposed portions is removed by dissolving by using a developer such as water, organic solvents or the like to form a photosensitive resin layer in the shape of image on the roll or plate.

The photosensitive resin or film employed can be a photo-sensitive diazo resin or rubber such as diazonium salt or a quinonediazides, a photosensitive resin containing cinnamoyl groups such as polyvinyl cinnamate, and a photosensitive resin containing acryloyl groups such as nylon, acryl amides or acrylates. The developer can be water or an aqueous solution of a weak alkali or an organic solvent such as alcohol, xylol or trichloroethylene. The water or aqueous alkali are used for resins of lower molecular weight while the organic solvents are used for those with higher molecular weights.

The non-electrically-conductive resin employed in the present process can be those which are conventionally employed for related purposes. For example, the following resins can be used, optionally with a plasticizer: methyl methacrylate resin, polybutyral resin, alkyd resin, phenol resin (novolac type), epoxy resin, polyvinyl chloride resin, polyvinylidene resin, polyvinyl acetate resin, polystyrene resin, polyacrylate resin, polyethylene resin, polyurethane resin, xylene resin, polyvinyl formal resin or toluene resin.

Solvents which can be employed for the resins in the present process usually have a boiling point in the range 50 - 300°C. Although those having a lower boiling point can be employed, there is usually insufficient time for their application before evaporating occurs.

Illustrative solvents are ethyl acetate, xylene, methyl cellosolve acetate, methyl cellosolve, cellosolve acetate, butyl cellosolve, benzene, toluene, mixtures of these compounds.

Preferred combinations of resin and solvent which can be used in the present process are given as follows:

methyl methacrylate resin	methyl ethyl ketone (MEK), benzene, toluene
polyvinyl butyral resin	methanol, ethanol, methyl cellosolve acetate, acetone, cellosolve.
alkyd resin	xylene, ethyl acetate cellosolve, methyl cellosolve or benzene.
phenol resin (novolak type)	methanol, ethanol, isopropanol or benzene.
epoxy resin	xylene, cellosolve acetate, butyl cellosolve or benzene.
polyvinyl chloride resin	MEK, methyl isobutyl ketone (MIBK) or cyclohexanone.

polyvinylidene resin	MEK, MIBK or cyclohexanone.
polyvinyl acetate resin	xylene, methyl cellosolve acetate, cellosolve acetate or benzene.
polystyrene resin	xylene or toluene.
polyacrylate resin	xylene or benzene.
polyethylene resin	xylene, ethanol or methyl cellosolve
polyurethane resin	used as produced in liquid state without addition of solvent
xylene resin	ethyl acetate, xylene, methyl cellosolve or benzene.
polyvinyl formal resin	ethanol, methyl acetate, acetone, MEK or cellosolve.
polybutene resin	xylene or cellosolve.

The above-mentioned solvents are examples of mutally soluble solvents although they can be used in the form of single solvents as well as mixtures. Moreover they can be used not only to provide a solution but also to give an emulsion.

The plating in the present process does not require a special plating bath. The plating will usually be of nickel and those baths conventionally used for plating nickel can be employed, for example a nickel sulfamate or nickel sulfate bath can be used. As an illustration, for a nickel sulfamate bath the following formulation is preferred, with acceptable variations shown in brackets:

Nickel sulfamate	550 g/l (500 to 600 g/l)
Boric acid	40 g/l (35 to 50 g/l)
Nickel bromide	7 g/l (5 to 10 g/l)
Sodium 1,3,6-naphthalene sulfonate	7 g/l (2 to 10 g/l)
Sodium lauryl sulfate	0.05 g/l (<0.1 g/l)

Satisfactory plating is achieved using the following conditions:

bath temperature	45 to 60°C
pH	4.0 to 4.5
current density	8 to 20 A/dm^2
voltage	9 to 11 V
anode	electrolytic nickel

The formulation and conditions can be varied although we prefer to operate within the indicated ranges.

The non-metallic roll or plate use to remove the resin will typically be of a natural or synthetic rubber having a suitable hardness. As such, natural rubber (polyisoprene), nitrile rubber (acrylonitrile-butadiene copolymer), styrene rubber (styrene-butadiene copolymer), neoprene rubber, ethylene-propylene rubber, Hypalon (chlorosulfonated polyethylene), polyisoprene synthetic rubber, polyacrylate rubber (acryl ester copolymer), polybutadiene rubber, urethane rubber, silicone rubber, fluorine rubber (hexafluoropropylene) are effective. The hardnesses of the plate or roll of these rubbers are in the range of 10 - 100 in terms of Shore hardness. As for the roll pressure, a pressing using 0.5 - 10 kg/24.5 cm, preferably 1-4 kg/24.5 cm is preferable. If the resin thickness is 10 - 100 mm or less, one step removal may be sufficient, but if the thickness exceeds the above-mentioned range, two or more pressings are usually necessary.

By repeating the steps (b), (c) and (a') a sufficient number of times the metal plating is built up to the required thickness to give a screen which then is removed from the master roll or plate. The present process can be used not only to produce screens for printing, but screens for other purposes such as for the grill cutters of electric shaver or filters e.g. for juices.

An embodiment of the present process will now be described with reference to the remaining Figures of the accompanying drawings in which:

Figure 5 is a cross-section illustrating the process after steps (a) and (b) have been performed once, and before the step (c) has been performed for the first time;

Figure 6 is a cross-section illustrating the step (c) during which a rubber roll is employed to remove resin from projecting areas of the metal plating;

Figure 7 is a cross-section illustrating the process after steps (b), (c) and (a') have been carried out twice; and

Figure 8 is a cross-section illustrating the screen produced by the invention after removal of the resin and peeling off of the screen from the master roll.

The present process can be summarised as follows, referring to the Figures 5 to 8:

(a) Resin is embedded in the surface of a metal roll (or plate), or a membrane of photosensitive resin is formed thereon, in order to render areas of the roll non-electrically-conductive and thereby give the prepared master roll. For a nickel screen, nickel plating is then carried out for the first time.

(b) Next, a solution containing the dissolved resin is applied over the surface of the roll; the resulting state is as shown in Figure 5. Suitable modes of application for the resin include spraying, doctor coating and roll coating.

(c) Just after the application and while the resin is still undried, a roller or flat plate of non-metallic material having good ink-receptivity is applied at a fixed pressure to the resin-coated surface, as shown in Figure 6. The rubber-lined roll 5 has completed one traverse of the roll 1 and portions of the resin 4 are removed from projecting parts of the metal plating 3 while other portions of the resin remain on the surface of the master roll.

(a') Next, after drying of the roll in a conventional manner, plating is again carried out using a plating bath.

The present invention is illustrated by the following, non-limiting Examples:

Example 1

The surface of a metal master roll of circumference 640 mm and surface length 440 mm was engraved with 80 lines/inch and the lines were then filled with an epoxy resin. The surface was then plated in a bath of nickel sulfamate to a thickness of 40 microns. The resulting master roll was then dried and a coating solution of 20% polyvinyl acetate solution in butyl cellosolve was uniformly applied onto the master roll using a conventional rubber roll as a spreader. Next, before the coating solution had dried, the master roll with coating was contacted with a rubber roll having a Shore hardness of 30, a circumference of 400 mm and a surface length of 300 mm. The rubber roll was rotated under a load of 10 kg synchronously with the master roll at a rate of 3 cm/sec to rotate the master roll twice, and then the rubber roll was removed. The thus treated master roll was dried with hot air (80°C) until the coating would not adhere to a hand brought into contact therewith, degreased with a sponge carrying precipitated calcium carbonate, washed with water and then with 5% nitric acid solution. The resulting master roll was then plated again in a nickel plating bath to a thickness of 40 microns, i.e. a total plating thickness of 80 microns. The resultant hole diameter of the mesh formed was about 160 microns, which is to be contrasted with the hole diameter of 80 microns which is obtained when a plating thickness of 80 microns is built up in a single plating step. The division of the plating into two steps has thus made it possible to produce a considerably greater hole diameter. It will also be apparent that this Example could be modified to produce a high mesh screen having a small hole diameter e.g. 150 mesh.

Example 2

Plating was carried out following the general procedure of Example 1. The plating was divided into three steps and a coating solution of 20% novolac phenol resin dissolved in isopropyl alcohol was applied using spraying. A nitrile rubber roll was then employed to remove resin from projecting portions of the metal coating in much the same manner as in Example 1; the nitrile rubber roll had the same hardness and size as the rubber roll in Example 1 (hardness, 30; circumference, 400 mm; surface length, 300 mm). Using 2 coatings and 3 platings it was possible to produce a mesh with a hole diameter of 200 microns.

Example 3

A stainless steel plate (300mm x 300 mm) was coated with a light-sensitive resin (7% polyvinyl cinnamate resin solution in ethylcellosolve acetate) and a half tone image was printed, followed by development with trichloroethylene and washing with water. Thereafter nickel plating was carried out in a bath as with Example 1 to a thickness of 20 microns and the so-plated plate was dried. The plate was then dipped in a 20% solution of the polyvinyl cinncinnamate resin in ethylcellosolve acetate and a sheet of paper was then placed over the whole surface of the resin deposited on the plate. The plate with paper was then past between the nip of two rubber rolls rotating at 5 cm/sec at a load of 20 kg. The paper was then removed from the stainless steel plate and the plate dried, degreased and activated as in Example 1. Thereafter plating was carried out in a plating bath to a thickness of 20 microns. After 3 coatings and 4 platings a screen having a hole diameter of 220 microns was obtained.

Example 4

A master roll having the same dimensions as that employed in Example 1 was engraved

with a mesh of 150 lines/inch and the recesses thereof were filled with anepoxy resin (Araldite). Plating was then carried out in a nickel sulfamate bath as in Example 1 to give a nickel coating thickness of 20 microns. Resin coating was then effected as in Example 1 and the plating repeated for a thickness of 30 microns. Again, resin was coated as before and a third plating of 30 microns gave a total plating thickness of 80 microns. The resultant nickel sleeve had a hole diameter of 60 microns; this result is in contrast to that obtained when one employs a single nickel plating to build up a thickness of 80 microns which results in total loss of the holes.

The nickel sleeve produced by the divided plating treatment was set on a vertical coating machine and coated to a thickness of 30 microns with a photosensitive resin solution of 10% ethylene glycol-dimethacrylate in ethyl cellusolve. A line image of line width 200 microns was then created and by using a rotary printing machine with an aqueous acryl resin ink printing was carried out on paper with a stainless steel squeegee having a thickness of 0.2 mm and a blade tip length of 30 mm using a squeegee pressure of 3 kg/cm^2 and a printing speed of 40 m/min. In this way a beautiful line image could be reproduced by the printing; line images having such a line width cannot be obtained with nickel sleeves produced by the conventional method.

Example 5

The sleeve of 150 lines/inch prepared as in Example 4 was fitted over an iron roll having a circumference of 600 mm and a length of 1500 mm. A film-form photosensitive resin (Riston supplied by E.I. du Pont de Nemours & Co.) consisting of 90% poly(methyl methacrylate acrlonitirile acrylated glycidyl acrylate 65/10/25) and 10% triethylene glycol diacetate and having a thickness of 30 μ was wound around the sleeve. Cover films comprising polyethylene for the top surface and polyester for the bottom surface were applied and heat adhesion was then carried out in a continuous manner using an iron maintained at 160°C. Thereafter the sleeve was further processed as in Example 4 and printing was effected using trichloroethylene as a developer. It was possible to print sharp, fine lines having a line width of 200 microns.

Example 6

The surface of a stainless steel roll (SUS-27, JIS) of circumference 640 mm and surface length 400 mm was coated with a photosensitizer resin (polyvinyl cinnamate) to a membrane thickness of 5 microns. A negative line drawing containing 150 lines/inch mesh and a line width of 200 μ was printed on the membrane and development was carried out with a definite developer consisting mainly of xylol to expose the metal surface of unexposed areas. After degreasing and water-washing of the exposed metal, nickel plating was carried out in a nickel sulfamate bath to a nickel thickness of 40 microns. The plated roll was then washed with water, dried and uniformly coated with a coating solution of polyvinyl butyral in cellosolve acetate using a common rubber roll to spread the coating solution all over the surface of the plated roll. Before the coating solution had dried, a rubber roller having a Shore hardness of 60, a circumference of 700 mm and a surface length of 300 mm was brought into contact with the coated roll and a load of 10 kg was applied with synchronous rotation at a speed of 3 cm/sec. After two rotations of the stainless steel roll the rubber roll was removed. The stainless steel roll was then dried with hot air, degreased with 2% aqueous sodium hydroxide solution, washed with water, and plated again in a nickel plating bath to a thickness of 20 microns. Coating as before and a further plating of 20 microns gave a total plating thickness of 80 microns. The coated resin was then dissolved out using methy ethyl ketone, the nickel coating was removed from the stainless steel roll and the hole diameter of the nickel was measured. The hole diameter was found to be 60 microns. The resultant nickel sleeve screen was then fitted to a rotary screen printing machine after attachment of end rings. As a result, a line having a width of 200 microns could be reproduced.

Example 7

A photosensitive resin comprising a 7% solution of naphthoquinone-1,2-diazid-5-sulfonic acid novolak in ethylene glycol monomethyl ether was sprayed onto a stainless steel roll (SUS-27 JIS) having a circumference of 640 mm and a surface length of 400 mm to form a membrane of thickness 5 microns.

The coated roll was then exposed to a negative graduation mesh having 150 lines/inch and development was carried out with approximately 5% sodium hydroxide solution in order to expose the metal surface of unexposed areas. The thereby revealed areas of metal were degreased, washed with water and plated in a nickel sulfamate bath to a plating thickness of

40 microns. The plated roll was then washed with water, dried and uniformly coated with a coating solution of polyvinyl butyral in cellosolve acetate using a conventional rubber roll as a spreader. Before the coating had dried, a rubber roll of Shore hardness 60, circumference 700 mm and surface length 300 mm was brought into contact with the roll and a load of 10 kg was applied while effecting synchronous rotation at a speed of 3 cm/sec. After two rotations of the stainless steel roll the rubber roller was removed. The stainless steel roll was then dried with hot air, degreased with an aqueous dispersion of $CaCO_3$, washed with water and plated again in a nickel plating bath to a plating thickness of 20 microns. Further coating and then plating to 20 microns gave a total plating thickness of 80 microns. The polyvinyl butyral coating was then dissolved out using methyl ethyl ketone, the photosensitive resin was dissolved out with a weak sodium hydroxide solution and the nickel plating was drawn off from the stainless steel roll. The hole diameter of the shadow part (solid part) of the nickel plating was 60 microns and that of the highlight part was 10 microns. The plating was mounted on a rotary screen printing machine to effect printing after attachment with end rings. As a result graduations which could not previously be achieved were obtained.

Example 8

This example relates to a high-mesh filter. A cylindrical iron roll of diameter 60 mm and height 120 mm was made and its surface was polished and copper plated in a copper cyanide plating bath to a copper plating thickness of 200 microns. The copper surface was then polished to a mirror finish and 150 lines/inch holes were formed. The whole surface was plated in a chromium plating bath to a chromium plating thickness of 5 microns. The plated roll was then washed with water and dried. The recessed parts were then filled with epoxy resin and the surface polished to a smooth finish. The resulting matrix was nickel plated in three steps to increase its thickness respectively by 30, 25 and 25 μ; coating of resin solution being carried out between the platings as in the preceding Examples. In this way a product was obtained which was found to be most effective as a filter and which is particularly suited for filtration of juices.

WHAT WE CLAIM IS:-

1. A plating process for producing screens which comprises:
(a) plating a prepared master roll or plate with a metal plating;
(b) applying a non-electrically-conductive resin on to the plating;
(c) while the resin is still undried or uncured, using a material compatable with the resin to remove the resin applied to projecting areas of the metal plating and thereby expose the projecting areas; and
(a') plating metal on the projecting areas; the series of steps (b), (c) and (a') being carried out one or more times to build up the thickness of the metal plating to a required thickness.
2. A process according to Claim 1, when used for the production of a screen for printing.
3. A process according to Claim 1 or Claim 2, wherein the master roll or plate is made by a lacquer process.
4. A process according to Claim 1 or Claim 2, wherein the master roll or plate is made by Galvano process.
5. A process according to any preceding Claim, wherein said material compatible with the resin is a non-metallic roll or plate.
6. A process according to Claim 5, wherein said non-metallic roll or plate is made of a natural or synthetic rubber having a Shore hardness of 10 - 100.
7. A process according to any preceding Claim, wherein when in step c) the resin is removed by said material compatible with the resin, the contact pressure between the resin and said material is in the range of 0.5 - 10 kg/24.5 cm.
8. A plating process for producing screens which process is substantially as hereinbefore described with reference to and as illustrated in Figures 5 to 8 of the accompanying drawings.
9. A screen when produced by a method according to any one preceding claim.

MARKS & CLERK

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
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1591488 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1
PRIOR ART

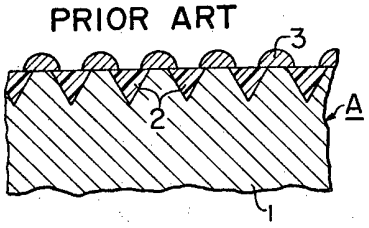


FIG. 2
PRIOR ART

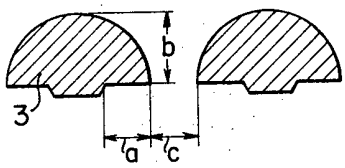


FIG. 3-1
PRIOR ART

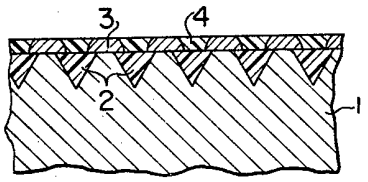


FIG. 3-2
PRIOR ART

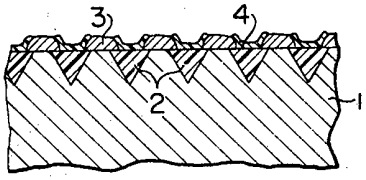
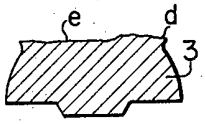


FIG. 4
PRIOR ART



1591488 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

FIG. 5

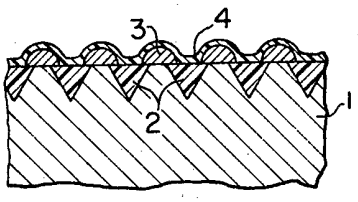


FIG. 6

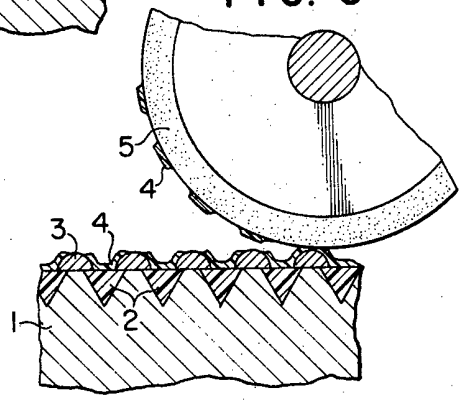


FIG. 7

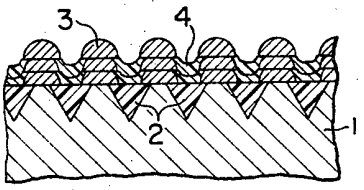


FIG. 8

