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METHOD OF PROCESS COLOR PRINTING WITH WATER-BASE INKS

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No Drawing. Continuation-in-part of application Ser. No. 549,169, May 11, 1966, which is a continuation-in-part of application Ser. No. 439,945, Mar. 15, 1965. This application Dec. 15, 1967, Ser. No. 690,773
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ABSTRACT OF THE DISCLOSURE

A heat resistant image having various colors, tones and hues is applied to a flat sheet material so that the latter may be subsequently subjected to heat and pressure, as in the bonding of the flat sheet material to corrugated material in the manufacture of corrugated fibre board, by the rotogravure process color printing on the flat sheet material of successively overprinted images from differently colored water-base inks containing heat resistant pigments and binders and having viscosities in the range between 16 and 22 seconds as measured with a No. 2 Zahn cup.

This patent application is a continuation-in-part of my copending patent application Ser. No. 549,169 which was filed on May 11, 1966, and which was, in turn, a continuation-in-part of Ser. No. 439,945, filed Mar. 15, 1965, both of the foregoing applications being now abandoned.

This invention relates to a method of process color printing and more particularly to a method of process color printing using water based inks.

Printing is many centuries old and has become a highly specialized and skilled art. The methods available for printing today include rotogravure, letterpress and silk screening. In gravure printing the image to be reproduced is etched on a highly polished surface so that the image to be reproduced is represented by a plurality of interstices etched in the highly polished surface. In gravure printing as presently known, ink is placed on the etched surface so that the ink fills the interstices forming the image to be printed. Any excess ink is then removed usually by means of a wiper or doctor blade. The material to be printed on is then brought into contact with the inked etched surface and the ink is transferred to the material to be printed on in order to form on the material the desired image. This procedure is accomplished by either printing on a material that is compressible so that it can be compressed and deformed to extend within the interstices and thereby transfer the ink from the interstices to the surface to be printed on or else the surface to be printed on consists of a smooth rigid surface such that the surface in coming in contact with the inked etched surface can create a vacuum between the cylinder or plate and the surface to draw the ink from the interstices to the surface to be printed.

In the foregoing description of printing by means of gravure, such term has been used in the generic sense and is intended to include also sheet fed gravure, rotogravure, off-set gravure and intaglio.

Printing by the gravure or intaglio method is generally performed with non-water soluble inks, that is with inks employing toluene or xylene as solvents. Although much work has been done on the development of water-base inks for gravure or intaglio printing, such water-base inks have not been previously used for process color printing by the gravure method and, in fact, the prior art teaches that water-base inks cannot be used for process color printing, particularly by the gravure method.

In process color printing by the gravure method, three basic colors plus black are generally used in order to attain a multitude of colors, shades and hues. Thus, for example, if the primary colors such as yellow, blue and red are used plus black any desired combination of multiple colors and hues can be obtained in order to reproduce any image in any desired tones. This is accomplished by process or over-lay printing in which an image is first printed in one basic color and then one or more over-lays are printed on the first and subsequent images in order to obtain the desired color combinations and image. The detail obtained in process color printing is dependent to a large extent in the present forms of process color printing on two basic factors, namely, screen size and ink viscosity. In gravure printing, for example, the screen size represents the number of interstices per square inch. In present forms of gravure printing a screen size of 65 mesh is considered coarse with resultant poor resolution printing, whereas a mesh size of 150 is considered fine printing with good resolution. The greater the number of the mesh normally, the less ink that is required to be transferred to the surface to be printed on, which results in finer printing quality and greater resolution or detail.

The viscosity of the non-water soluble inks heretofore exclusively used in gravure process color printing is also important since if the viscosity of the ink is too low poor resolution will be obtained due to a spreading or merging of the ink from one interstice to the other, thereby resulting in an image having uneven color gradations. Conversely if the viscosity of the ink is too high the transparency of the ink color is either destroyed or lessened thereby resulting in extremely poor color printing and image reproduction. The non-water soluble inks presently being used for gravure process color printing consist of a pigment plus a resin or binder which facilitates the binding or adhering of the pigment to the surface to be printed, and a solvent in which the pigment and resin are soluble and which acts as a carrier for these substances. The solvents are generally materials having a carbon radical such as ketone, alcohol, esters, etc. The non-water soluble inks presently being commercially used in gravure, letter press and other types of printing have numerous disadvantages. These disadvantages are as follows:

(1) Poor heat resistance. The inks melt or become plastic at relatively low temperatures.

(2) High cost of resins and solvents. This is true for mixing, cleaning and storage.

(3) Flammability. This is due primarily to the solvents.

(4) Toxicity. This is due primarily to the solvents.

(5) Purity. The Pure Food and Drug Administration prohibits the use of a non-water soluble ink on any surface which is to come into contact with food. Conversely the Pure Food and Drug Administration has approved the use of water-base inks on surfaces which are to come into contact with food.

(6) Shorter plate or cylinder life due to the carbons in the solvent which are abrasive.

(7) Greater inventory. Various shades must be maintained in stock since they cannot be blended.

(8) Solvent evaporates quickly thereby rendering difficult the control of the ink viscosity.

There are many applications today in which it is impossible to print any image on a surface by means of process color printing using a non-water soluble ink because of subsequent manufacturing operations or end use of the product. Thus, for example, in the manufacture of corrugated board the corrugated board is generally formed by subjecting the sheets thereof to a high degree of heat in order to bond the corrugating medium to the liner board facings. Although it is presently known and practiced today to print with a non-water soluble ink on finished corrugated board by means of letter press

printing it is both impractical and impossible to print on finished corrugated board by means of rotogravure process color printing. Thus, where it is desired to have rotogravure process color printing on corrugated board it is necessary that the rotogravure process color printing be accomplished on the liner board before it is joined or bonded to the corrugated board. This has been and is being done commercially, but only with non-water soluble inks. However, rotogravure process color printing with non-water soluble inks on the liner board before it is joined to the corrugated sheet or board has important inherent disadvantages. Such disadvantages result from from the fact that the pigments deposited on the printed surface by non-water soluble inks are solid at room temperature, but become soft or plastic at elevated temperatures. Thus, when, during the manufacture of the corrugated board, elevated temperatures are used to bond the printed liner board to the corrugated sheet, the non-water soluble inks previously deposited on the liner board will be rendered soft or plastic, resulting in smudging, blurring and scratching of the printed image due to contact with heating plates, etc. Accordingly, it has heretofore been considered undesirable to rotogravure process color print with the conventionally used non-water soluble inks on liner board prior to the bonding thereof to corrugated sheet.

Various attempts have been made to use inks which did not have the above noted deficiencies of non-water soluble inks in rotogravure process color printing. In this regard, many people have realized the desirability of using a water-base ink in process color printing. The reason for this is that a water-base ink has many advantages over a non-water soluble ink. Some of these advantages are as follows:

(1) Water-base inks are non-flammable which results in a saving in equipment cost and insurance rates over the use of non-water soluble inks.

(2) Water-base inks can be saturated with wax or polymer solutions, whereas some if not most non-water soluble inks cannot.

(3) A flat matte finish can be obtained when desired through the use of water-base inks, whereas this cannot be obtained through the use of non-water soluble inks.

(4) There is no residual solvent odor when water-base inks are used.

(5) Water-base inks as contrasted to non-water soluble inks have high heat resistance. This as noted above is particularly valuable and important and in fact imperative in the manufacture of corrugated fibre board. Thus the heat that is utilized in the manufacture of corrugated fibre board which is damaging to non-water soluble inks which have been process color printed does not effect the printed image when water-base inks are used.

(6) Good hold out and excellent printing surfaces can be obtained for other types of inks when water-base inks are utilized. Thus the utilization of a water-base ink permits over printing with any other inks which are also water-based, which is not true of non-water soluble inks.

(7) Economy. Water-base inks use as their diluent water which is a commodity either obtainable free of charge or at a minimum cost. The cost of a water-base ink is much less than a non-water soluble ink which must use as the solvent a manufactured material which, of necessity, has a higher cost than water. Another reason why water-base inks are more economical to use than non-water soluble inks is that the solvent used with a non-water soluble ink evaporates rapidly and must constantly be replaced in order to maintain the viscosity of the printing ink. When a water-base ink is used the water functions as the diluent and will evaporate slower than solvents used in non-water soluble inks and of course be replaced at virtually no cost. A further reason why water-base inks are more economical than non-water soluble inks is that the printing equipment can be cleaned with the same diluent used with the water-base ink, namely, water, which again is a commodity that can be obtained free of charge or at a minimal cost. Thus, the cleanser used to clean the printing equipment costs virtually nothing. In contrast to this, when printing with a non-water soluble ink, the equipment must be cleaned with the fairly costly, synthetic solvent that is used as the part of the ink. As a typical example, one of the cheapest solvents presently obtainable is methanol which costs approximately fifty cents per gallon. When rotogravure process color printing is used for example it takes approximately 10 gallons of solvent to clean each large printing cylinder. Thus, in rotogravure process color printing using four large cylinders and a non-water soluble ink, a cost is incurred each day of approximately $20.00 in order to clean the cylinders. This is to be contrasted with the fact that, when a water-base ink is used the clean-up can be accomplished free of charge since the solvent being used to clean-up is water. Since the average printing unit includes many other items in addition to the cylinders, it will be apparent that the cost of cleaning when a non-water soluble ink is used is far greater than the estimate given above. For example, in a typical large printing press which is adapted to print in four colors it has been found that the clean-up cost using a non-water soluble ink is approximately $70.00, which is a cost that must be incurred each day. Another saving accomplished through the use of a water-base ink is the simplification of the clean-up process. Since the solvent being used to clean-up is water which can generally be obtained free of charge it is only necessary to virtually turn a hose on the various pieces of equipment to be cleaned and to allow the water to run until the unit is sufficiently cleaned. Conversely, when a non-water soluble ink is used and the clean-up must be accomplished with a solvent that is to be purchased, the clean-up must of necessity progress slower and thereby require more time and expense since the solvent must be used judiciously and in a manner to obtain maximum cleaning.

A further economy achieved through the use of a water-base ink as contrasted to a non-water soluble ink is that the solvent used for cleaning does not have to be stored when a water-base ink is used. In printing systems utilizing a non-water soluble ink it is necessary to purchase and store large quantities of flammable solvents which involves an expense not only because of the purchase but also because of the storage. Because they are volatile and flammable the solvents also necessitate additional expenditures for items such as insurance, maintenance, safety, etc.

Although it has been recognized for many, many years that the use of a water-base ink has numerous and varied advantages over the use of non-water soluble inks it has nevertheless been considered impossible to use water-base inks in applications involving process color printing, particularly by the rotogravure method. Many attempts have been made in the past to utilize water-base inks in process color printing, but these various and sundry attempts have met with failure. Among the reasons given in the literature for these failures by various ink companies, builders of printing machinery and gravure technical associations is that it was impossible through the use of water-base inks to obtain the resolution that could be obtained with non-water soluble inks. Thus, although it has been recognized for many, many years that it would be desirable in process color printing to utilize a water-base ink, it has heretofore been considered impossible to use a water-base ink in process color printing, particularly in rotogravure printing.

In view of the foregoing the primary object of the present invention is to provide a method of rotogravure process color printing utilizing a water-base ink.

A further object of the present invention is to provide a method of rotogravure process color printing which can be utilized in the manufacture of corrugated fibre board and which will provide heat resistant printed images so that, when such images are subjected to the heat en-

countered during the manufacture of corrugated fibre board, the blurring, running, lack of resolution, streaking, etc. which has heretofore been encountered, will be avoided.

These and further objects and features of the invention will appear from a reading of the following detailed description of the invention. The invention will be described with specific reference to the use of rotogravure process color printing on the liner board used in the manufacture of corrugated fibre board. It is to be understood, however, that this is not to be construed as limiting the invention but merely as descriptive of one particularly advantageous application of the invention. The invention in its broadest aspect is directed to a method of rotogravure process color printing using water-base inks.

The manufacture of corrugated fibre board is accomplished by interleafing between a pair of liner boards or facing boards the corrugating medium. This can, of course, be multiplied to double or triple wall corrugated by interleafing between sheets of liner board additional sheets of corrugated fibre board. The present invention, however, will be described with reference to single ply corrugated fibre board, i.e. a corrugated medium contained or bonded between two liner boards. It is to be understood that one or both of the liner boards may have printing material thereon.

As stated above, whenever it was desired to print on any surface through the utilization of process color printing the prior art has always utilized a non-water soluble ink. The reason for this is that experts in the field have always maintained that it was impossible to use a water-base ink in process color printing particularly by the rotogravure method. In the method of process color printing in the prior art therefore the various cylinders to be utilized in rotogravure process color printing first had etched therein the interstices forming the desired image. The non-water soluble ink was then in some manner transferred to the etched cylinder and the material to be printed on is brought into contact with the inked etched surface and the ink is then transferred from the interstices to the surface to be printed. Prior to this step, however, excess ink is removed from the etched cylinder by means of a doctor blade. This doctor blade can be arranged at an angle of between 0 and 90 degrees with respect to the etched cylinder, the angle to be used being determined by the viscosity of the ink and the screen size. In the applications utilizing non-water soluble inks, the angle of this doctor blade with the etched cylinder was generally in the neighborhood of 80 degrees for 150 mesh.

In process color printing utilizing non-water soluble inks it is important that the viscosity of the ink be carefully controlled. The ink consists of a pigment plus a resin plus a solvent such as a ketone, ester, alcohol, etc. The quantity of solvent used depends upon the viscosity of the ink desired. The viscosity of the ink is important since if the viscosity is too low the ink will tend to run and smudge and blur resulting in poor resolution, whereas if the ink is too viscous, i.e. too thick, very little transfer will be obtained from the printing surface and the color gradations will not be obtained because the ink tends to lose its transparency as the viscosity increases. In accordance with the prior art teaching of the use of non-water soluble inks in process color printing, the viscosity of the inks must be maintained in the range between 25 and 40 seconds measured with a No. 2 Zahn cup at a temperature of 68° F. with the particular viscosity within that range, depending primarily upon the speed at which the material to be printed is passing over the inked etched cylinder, the drying time required and the number of interstices per square inch. Thus, for example, in the prior art methods utilizing a non-water soluble ink in rotogravure process color printing with a screen size of 150 mesh and the material to be printed passing the inked etched cyclinder at a speed of 1,000 feet per minute, the viscosity of the ink would normally be approximately 30 seconds measured with a No. 2 Zahn cup at 68° F.

In the manufacture of corrugated fibre board, the corrugated board is subjected to a temperature of approximately 300° F. in order to bond the liner board to the corrugated material. If the liner board has been color process printed with a non-water soluble ink, the above bonding temperature will render the printed surface plastic or soft so that the printed surface will be distorted, and the resolution materially decreased during the manufacture of the corrugated fibre board. For this reason it has heretofore been considered impossible to print on liner board by process color printing where the liner board was to be subsequently formed into corrugated fibre board with the printed surface coming into contact with the hot plate. One method attempted by the prior art in order to overcome this difficulty was to apply a varnish coat over the process color printed image before the liner board was bonded to the corrugated board. The purpose of this varnish coat, of course, was to prevent the heat from reaching the process color printed material and thereby softening the thermoplastic ink. The heat was minimized by the varnish coating which tended to act both as an insulator and as a reflective surface thereby to a certain degree preventing the temperature of the printed surface from rising to a point where plasticity was reached. This, however, has proven to be an extremely expensive operation and one that is considered impractical. For this reason, prior to the present invention, liner board which was to be used in the manufacture of corrugated fibre board has not been process color printed. This has prevented corrugated fibre board from being used in many applications.

However, I have discovered that, contrary to the teaching of the prior art, water-base inks can be successfully used in rotogravure process color printing provided that such inks are used at viscosities in a range which is different from the range of viscosities used for non-water soluble inks in rotogravure process color printing. In accordance with this invention, water-base inks are used successfully in rotogravure process color printing, thereby to achieve all of the previously stated advantages of such inks, by maintaining the viscosity of the water-base inks in the range between 16 and 22, and preferably between 18 and 20, seconds as measured in a No. 2 Zahn cup at a temperature of 68° F. It should be noted that inks having viscosities in the above range characteristic of this invention were previously believed to be impractical and even completely unsuited for use in rotogravure printing. Of course, the particular viscosity selected within the stated range depends upon the speed of movement of the material to be printed, the strength or weakness of the color being printed, the desired transparency of the color, the mesh or screen size of the cells in the rotogravure cylinder, the depth of the cells, the nip pressure between the gravure and the back-up or impression cylinders, the hardness of the rubber or other cover or blanket on the impression cylinder, and the receptivity of the surface being printed for the ink.

In the practice of the present invention, any existing water-base inks formulated for use in gravure or intaglio printing may be employed for rotogravure process color printing provided that the viscosity of such inks is adjusted to lie within the above indicated range characteristic of the invention. Such water-base inks essentially comprise a water dispersible pigment, a water dispersible, heat resistant binder, and water, with other additives being usually included, such as, a water-soluble solvent, a saponifying agent etc.

As a practical matter, the pigments may be obtained in paste form from various commercial sources, such as, Interchem Printing Inks Division of Interchemical Corporation, Sinclair and Valentine Co., and General Printing Ink Corp. The pigment pastes are intended to be mixed

with an extender or varnish, also available commercially from the indicated sources, and also with additional water, if necessary to achieve the required viscosity. The ratio of pigment paste to extender is varied to achieve the desired color intensity, and the amount of water is varied to adjust the viscosity of the resulting ink to within the range characteristic of this invention.

Assuming that an image is to be reproduced by rotogravure process color printing with water-base inks in the three primary colors (red, yellow and blue) and black, formulations of pigment pastes and an extender suitable for that purpose are given below merely by way of example:

RED PIGMENT PASTE

	Parts by weight
Barium Lithol Red pigment	22.5
Tributyl phosphate	0.5
Mekon wax (a petroleum hydrocarbon wax available commercially from Warwick Chemical Co.)	1.5
Fumarated rosin	5.0
Esterified rosin	3.5
Alpha protein	1.0
Urea	8.0
Ammonium hydroxide	1.0
Water	57.0

YELLOW PIGMENT PASTE

Chrome Yellow pigment (containing at least 95% lead chromate)	44.0
Tributyl phosphate	0.6
Mekon wax	1.5
Fumarated rosin	8.0
Alpha protein	1.5
Urea	4.0
Ammonium hydroxide	1.0
Water	39.4

BLUE PIGMENT PASTE

Cyan Blue pigment (a blue copper phthalocyanine pigment available commercially from American Cyanamid Co.)	20.0
Tributyl phosphate	0.5
Mekon wax	1.5
Fumarated rosin	5.0
Esterified rosin	3.5
Alpha protein	1.0
Urea	8.0
Ammonium hydroxide	1.0
Water	59.5

BLACK PIGMENT PASTE

Carbon Black pigment	18.0
Tributyl phosphate	0.6
Mekon wax	1.5
Fumarated rosin	6.4
Esterified rosin	4.0
Alpha protein	1.2
Urea	8.0
Ammonium hydroxide	1.2
Water	59.1

EXTENDER

Casein	13.6
Fumarated rosin	12.6
Ammonium hydroxide	3.8
Isopropyl alcohol	10.0
Octyl alcohol	0.4
Hexylene glycol	4.0
Water	55.6

In each of the above pigment paste formulations, the pigment is designed to provide color to the ink resulting from mixing of the paste with extender and additional water, if necesary, and the pigment releases water more rapidly than the binder. The function of the binder is to lock the pigment to the substrate being printed and to protect it from abrasive forces.

The binder is considered the solid component of the vehicle. The water has several functions, namely, to disperse the binder and to carry the binder and the pigment into and out of the cells of the printing cylinder and onto the substrate being printed on and to evaporate immediately from the printing film thereby leaving a residue of pigment and binder which is observed as the printed image.

As mentioned above, the water is the principal means of controlling the viscosity of the water-base ink to bring the viscosity within the range characteristic of the present invention. Conversely the strength or intensity of color provided by the ink is governed principally by the ratio of the amount of pigment to binder. Thus, if a particular color has been blended by mixing one of the pigment pastes with the extender of the above examples and with water, and it is found for example, that the color intensity is too great and has to be toned down, this is accomplished by adding to the mixture an additional quantity of extender until the desired hue or color is achieved. Once this has been accomplished the viscosity may have risen above that desired and the viscosity is, in that case, reduced to the required level by adding a quantity of water to the mixture sufficient to reduce the viscosity to the level desired. Once the desired color values have been obtained and the viscosities corrected, a proof is run in order to determine if the proper color balancing has been achieved. Any color balancing that is necessary is then achieved by adding additional extender or pigment paste to the particular color and additional quantities of water in order to again arrive at the viscosity required. The rotogravure printing press is then run at the predetermined selected speed and the results observed. If so called crawling or orange peeling is observed this is an indication of an incorrect viscosity. This is indicated by improper ink deposition onto the printed surface and is corrected by slightly raising the viscosity of the ink. If improper transfer of the ink from the printing surface to the area being printed is found to be taking place this is corrected by slightly lowering the viscosities since it is indicative of the fact that the ink is too viscous and is not flowing properly. It has been found, however, in practice that only minor variations are necessary.

In practicing the method of rotogravure process color printing according to this invention, use may be made of any conventional multicolor rotogravure printing press, such as, a commercially available Motter four color, gravure publication press. The rubber blanket or cover in the backup cylinder of each printing couple should have a hardness between 85 and 90, as measured by a Shore Durometer. The nip pressure between the gravure and back-up cylinders may be varied between 200 and 375 pounds per linear inch. The screen or mesh size may vary between about 65 mesh per inch and about 300 mesh per inch, with 120 to 150 mesh per inch being adequate for fine resolution, and the ratio of the width of each cell thus etched in the surface of the gravure cylinder to the depth of the cell may lie in the range between 2.2:1 to 2.7:1. The material to be printed, for example, the liner board subsequently to be manufactured into corrugated fibre board may have a smoothness giving a reading between 35 and 75 on a conventional Sheffield Smoothness Tester, which respectively represent substantially smooth or glossy surfaces and substantially rough or porous surfaces. It will be apparent that the nip pressure is varied within the above range to provide the requisite take-up of ink from the cells of the gravure cylinder by the material to be printed on, which material will have a considerable variation in its receptivity for the ink within the range of smoothnesses indicated above.

The press speed, that is, the speed at which the material to be printed moves past each gravure cylinder is also subject to substantial variation upward from a mini-

mum speed of at least 150 feet per minute. It is to be understood that the higher the press speed, the lower will be the viscosity of the water-base ink to be used, with such viscosity always being in the range of 16 to 22 seconds measured with a No. 2 Zahn cup. The reason for this is that, at higher press speeds, less viscous water-base inks can be used without smearing or blurring of the image as the printed image reaches the drier of the press very soon after the application of the image to the material being printed and less time is available for the applied ink to flow while in its highly liquid state.

The following is a chart showing the correlation between viscosity and press speed for a screen size of 150 interstices per inch.

Viscosity (seconds with a No. 2 Zahn cup):	Press speed ft. per minute
16	500
17	400
18	300
19	200
20	150

It is to be understood that the foregoing is merely illustrative of the invention and not to be construed as limitative. For example, for the lowest viscosity given the press speed is indicated as 500 ft. per minute, but it is to be understood that is a minimum speed for that viscosity and that the press speed can be increased substantially above this speed and still maintain the same viscosity in order to obtain desirable results.

Once the press is in operation another variable which can be adjusted is the angle that the doctor blade makes with the inked gravure cylinder. Due to the fact that the present invention is practiced with an ink having a much lower viscosity than non-water soluble inks, it is possible to dispose the doctor blade at a angle relative to the cylinder that is smaller than heretofore thought possible. The reason for this, of course, is that the lower viscosity of the ink permits a lower pressure to be applied on the doctor blade in order to maintain it in position. For example, in conventional rotogravure process color printing utilizing a non-water soluble ink, the angle that the doctor blade makes with the inked gravure cylinder is approximately 80 degrees, whereas in the practice of the present invention this angle is generally in the neighborhood of approximately 45 to 60 degrees. This reduced pressure and angle increases the longevity of the gravure cylinder.

The present invention has been practiced successfully with numerous and varied qualities of paper and qualities of paper surfaces. These have ranged from extremely smooth sheets having a virtually glossy surface with little if any ink absorption qualities, to surfaces of extremely rough texture having high absorption qualities. The invention however has been found to be subject to consistently uniform results regardless of the surface on which printing is being accomplished. If desired, after the sheet has been process color printed in accordance with the present invention, it is possible and often desirable to cover the process color printed material with a protective coating, for example of an overprint varnish. This is often desired for esthetic reasons in order to make the surface scuff proof, highly reflective, heat resistant, mildew proof, etc. Since the inks used in the practice of the present invention are all water-based it is of course practical and possible to use a water-base varnish which generally is not possible with non-water soluble inks. This is important since under present Federal Drug Administration regulations a surface printed with a non-water soluble ink cannot be brought into contact with any types of food designed for human consumption. Thus by printing in accordance with the present invention, that is, with a water-base ink, the surface itself can be brought into contact with food substances. In addition it is possible to cover the printing with a water-base varnish such that the resultant surface can also be brought into contact with food substances under present FDA regulations.

A suitable overprint varnish for protecting process color printed material formed with water-base inks in accordance with this invention may have the following formulation:

	Parts by weight
Casein	14.0
Fumarated rosin	18.1
Ammonium hydroxide	5.2
N-propyl alcohol	8.0
Mekon wax	1.5
Tributyl phosphate	.4
Water	52.8

What has been described is a method of process color printing utilizing water-base inks within a specific range of viscosity. The required viscosity is, of course, maintained during the operation of the press by periodically testing the viscosity of the ink supplies. Since the water in which the pigment and binder are dispersed is not volatile, it does not evaporate rapidly. Further, since the ink is continuously pumped during operation of the press, the viscosity does not vary, except by reason of the evaporation of water, which can be easily made-up as required.

This invention has particular significance to the manufacture of various articles which are subjected to heat after printing, since a water-base ink is heat resistant, as contrasted with a non-water soluble ink which becomes plastic or soft when subjected to heat. By reason of the foregoing, it is further contemplated by this invention, to effect the rotogravure process color printing with water-base inks of liner board or stock before the bonding thereof to corrugated material in the manufacture of corrugated fibre board. Since the liner stock is not yet bonded to the corrugated material, it can have process color printing effected thereon by the gravure method to achieve prints of the quality and resolution characteristic of that method. Since water-base inks are employed in the rotogravure process color printing in accordance with this invention, the resulting multi-color prints are heat resistant and thus are not blurred or otherwise adversely affected when the printed liner board is subjected to heat during the subsequent bonding to the corrugated material. Further, surfaces printed in accordance with the present invention are non-toxic and, under present FDA regulations, can be brought into contact with food designed for human consumption.

In the following claims the phrase process color printing is meant to define a printing process wherein two or more colors are used to reproduce a multicolor image, the colors being overprinted in order to obtain the desired colors, hues and tones.

What is claimed as my invention is as follows:

1. In the method of rotogravure process color printing of flat sheet material to obtain an image thereon having a plurality of colors, tones and hues by passing the sheet material through successive printing couples each consisting of gravure and back-up cylinders to successively overprint on a surface of the sheet material corresponding imprints in differently colored inks, with each imprint being dried before the overprinting thereon of the next imprint, the improvement of providing each printing couple with a cover on its back-up cylinder having a hardness between 85 and 90 as measured by a Shore Durometer and with a nip pressure between the cylinders in the range from 200 to 375 pounds per linear inch of the contact line therebetween, limiting the mesh size of the cells in said gravure cylinder of each couple to the range of from 120 to 150 mesh per inch with each cell having a width to depth ratio in the range from 2.2:1 to 2.7:1, effecting the passage of the sheet material through the successive printing couples at a speed of at least 150 feet per minute, and employing for each of the successively overprinted images a water-base ink containing heat resistant pigments and binders and having a viscosity, as measured with a No. 2 Zahn cup, in the range between 22 for said minimum speed of 150 feet per minute and

16 for higher speeds, whereby the image constituted by said imprints is heat resistant and may be provided with fine resolution.

2. The method according to claim 1, further comprising the step of bonding the flat sheet material thus printed to a corrugated sheet material through the application of heat and pressure, which heat is well resisted by the heat resistant image constituted by said imprints formed of the water-base inks.

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