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C. R. JOHNSON ET AL

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METHOD OF PRINTING AND APPARATUS THEREFOR

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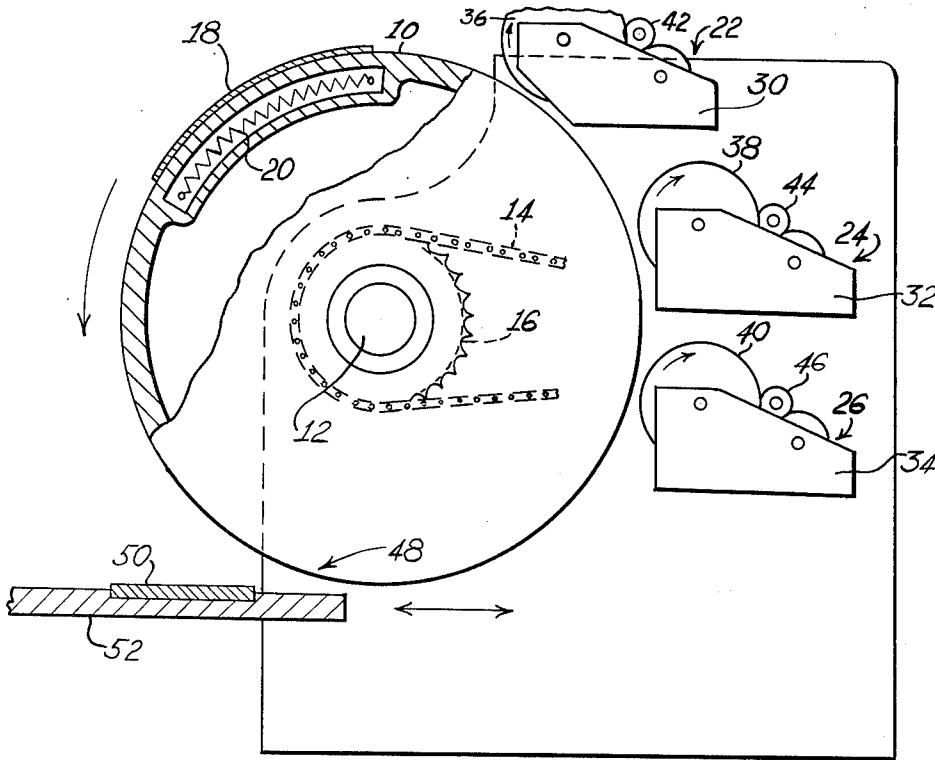


FIG. 1

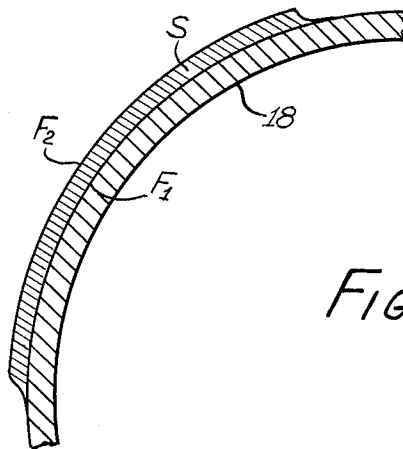


FIG. 2

INVENTORS,
CARL R. JOHNSON & KENNETH TRIPP
BY
Frederick D. Goode,
Atty.

3,255,695

METHOD OF PRINTING AND APPARATUS THEREFOR

Carl R. Johnson, Marlboro, and Kenneth F. Tripp, Peterborough, N.H., assignors to Markem Machine Company, Keene, N.H., a corporation of New Hampshire
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This invention relates generally to the art of film formation and film transfer and more particularly to a novel method and apparatus relating to the decoration of surfaces by offset printing techniques with an immediately dry image transfer of controlled thickness. This disclosure constitutes a continuation-in-part of our copending application Serial No. 194,936, filed May 15, 1962.

The printing or decorating of objects is conventionally accomplished by a variety of means, among which are direct printing, the silk screen process, applying transfers, or by conventional offset printing. Each of these processes has one or more shortcomings which limit its effectiveness in high rate of production applications requiring opaque transfers with accurate detail. For example, neither in the processes mentioned nor in any other similar processes is it feasible to change the printed design or type after each impression, as in the case of articles printed with consecutive number, except at prohibitive cost in changing screens or transfers or with unsatisfactory results in dry offset printing because of blurring of the impression due to build-up of traces of ink retained on the offset surface after each impression.

In the silk screen process ink is squeezed through a stencil by a squeegee blade onto the object being printed. The process allows the laying down of heavy layers of ink of reasonably good definition, but it is generally possible to screen only one color at a time and the production rate is slow because of the necessity of passing the squeegee over the stencil area in order to obtain the image transfer. Furthermore, the heavy thick layer produced requires a relatively long drying time.

The method of applied transfer comprises applying a pre-printed multi-color design which gives good coverage and good definition, but it is an expensive practice requiring the pre-printing of the design on a removable backing in another location (which involves inventory and spoilage problems because of packing, storage, and deterioration) and because of the relatively low production rate resulting from the necessity of peeling the transfer from its backing and applying it to the piece being printed or decorated, or from the use of special solvents or adhesives to bond the transfer to the desired surface.

Conventional offset is a high-speed multicolor process which applies several colors simultaneously on an article to be printed, but has a definite disadvantage in the fact that low color density results because of the thinness of the highly solvent film which must be applied by the system in order to impart the desired drying characteristics. Moreover, the necessity for having an ink which will remain working properly in the high-speed inking mechanism means that the print is not dry on the piece as soon as it has been printed, but that special drying mechanisms or a substantial subsequent drying time is required.

Additionally, in all instances of offset printing, after each cycle of printing operation, it is found that each impression results in a residual layer of ink left on the offset pad which, if not regularly removed, ultimately accumulates so as to render blurred and indistinct impressions. This, of course, imposes an additional burden on the press operator of having to perform a cleaning operation of the pad at regular intervals.

The present invention, however, overcomes these aforementioned prior art deficiencies by introducing a novel concept heretofore unknown in the prior art. Generally our invention includes in its scope the feature that when a uniform fluent wetting layer of film forming material is deposited upon a carrying surface of particular composition, and controlled film formation transition is induced into such a fluent layer, this formation reaches a transitory condition of partial dryness whereby it becomes possible to completely separate this partially formed film intact, as an integral mass from its carrying surface without the use or aid of any film releasing agents.

Though these discovered principles have a wide variety of application which will become obvious in light of the foregoing disclosures, we have for purposes of description and illustration selected the field of offset printing as typical of these areas of application.

It is accordingly among the objects of this invention to provide a process and apparatus for depositing multiple layers of controlled thicknesses of ink at very high speeds on an object or series of objects being printed so that they may have the opacity or color density of silk screen process prints and yet are for all practical purposes immediately dry.

Another object of this invention is to provide immediately substantially dry multicolor image transfers of high quality, yet to do so with a process which differs from the decalcomania type transfer method with its attendant inventory deterioration, and low production drawbacks.

Still another object of this invention is to provide a process and apparatus for producing, at the high speed of conventional offset printing, multicolor image transfers that are immediately substantially dry, yet of a density not heretofore obtainable by conventional offset methods.

Yet another object of the invention is to provide a process and apparatus which retains the multicolor advantages of the dry offset principle in printing on various articles, but provides additional versatility by enabling the characters or decorations printed to be changed after each image transfer is made, as is required, for example, in consecutively numbering articles being printed with an automatic indexing printing head, without interrupting the cyclic operation of the process to remove residual deposits of ink from the offset pad.

A still further object of this invention is to provide generally a film forming and transfer method and apparatus which can rapidly produce and transfer intact a continuous or interrupted integral film of prescribed material with a controlled thickness to selected objects in a substantially dry condition suitable for immediate subsequent operations, if desired.

A yet further object of this invention is to provide a process for separating and removing a thin, partially dry film from its carrying support without the necessity or use of any release agents.

With these and other objects in view, as will herein-after more fully appear, and which will be more particularly pointed out in the appended claims, reference is now made to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 shows a schematic view of a preferred embodiment of the apparatus of the herein invention, depicting an offset pad with a heating element contained therein; and

FIGURE 2 depicts an enlarged cross-sectional view of an ink film carried by the offset pad.

With particular illustrative reference to offset printing, we have discovered that when a temperature controlled offset pad exhibiting a lower surface affinity for an ink film than the film exhibits for the article to be printed is maintained within prescribed temperature limits, and

has applied thereto a fluent layer of film-forming ink of suitable compounding, the predetermined time of exposure of such an ink layer on the temperature controlled offset pad so alters the physical state of the layer that it is converted from its initial fluid condition with little cohesive integrity to a partially dry ink film which exhibits considerable cohesive integrity while concurrently attaining a transitory condition of substantial adhesive tack on its exposed surface. If at the conclusion of this predetermined time interval the ink film is pressed into intimate contact with the article to be printed, a complete transfer of the film, intact, from the offset pad to the article being printed, as an integral mass is effected. At this moment of intimate contact the ink film in its converted state presents a film surface to the article being printed which exhibits a greater adhesive tenacity therefor than the opposite film surface exhibits for the temperature controlled offset pad which was preselected to exhibit a low affinity for the particular ink film being employed. An important result of this controlled occurrence is that the partially dry ink film is completely transferred from the offset pad intact to the item being printed without the use of any release agent thereby leaving the pad, or other carrying surface such as type face, free of residual ink and immediately ready for the next ink application with no requirement for intermittent cleaning thereof. We have demonstrated that this process can be carried out at speeds comparable to conventional dry offset printing presses. Because the transferred image is for all practical purposes immediately dry, our invention permits definite economies in equipment and floor space requirements by eliminating drying apparatus and moreover offers a versatility in film transfer techniques in general and offset printing in particular which has heretofore been unknown in the prior art.

In order to achieve these results, we have discovered that certain physical and chemical parameters relating to the (1) film forming material (e.g. ink), (2) film carrying surface (e.g. offset pad or type face), and (3) film receptor surface (e.g. article to be printed) should be established as follows:

(1) The ink must necessarily be of film forming composition and be capable of wetting the offset pad or other carrying surface when initially applied thereon in its fluent state.

(2) At the moment of transfer, the film carrying surface or offset pad should, in relation to the article being printed, exhibit a relatively non-adhesive (i.e. highly adhesive) characteristic for the particular converted film of ink or other film material carried thereon.

(3) The film receptor surface or article to be printed on should exhibit characteristics opposite to those of the carrying surface, i.e. at time of image transfer it should be highly adhesive to the film being transferred to it. In other words, at moment of film transfer, the film receptor surface should exhibit a greater adhesive attraction for the film than does the film carrying surface.

Film forming compositions are well known in the art and no particular explanation of this parameter is deemed necessary.

However, predicting or ascertaining the conditions to fulfill the requirements of the remaining two parameters present definite problems. The interrelation between the ink film and the carrying surface on the one hand are distinctly related though opposite in effect to the interrelation between the ink film and the receptor surface on the other, in terms of adhesive attraction. It is thought that such adhesive attraction, or lack of it as the case may be, can be equated in terms of surface free energies, that is, the available molecular energy existing on the surface of one material for combination with compatible molecular energies existing on another surface brought in contact therewith, binding them together.

As an aid in understanding this invention we can present certain findings relative to the adhesive behavior of

surfaces in intimate contact with one another. Certain theories have been advanced which state that the extent or degree of mutual attractive affinity which materials exhibit for each other are due to great measure to the presence and interaction of so called Van der Waal forces. For example, when two surfaces are brought into intimate contact, these Van der Waal forces, representing the residual surface energies of these surfaces, coact between their respective atoms and molecules in such a manner as to forcibly combine together. These theories further state that where a strong adhesive bond is required, the material on which the adhesive is spread should have a higher residual surface energy than the adhesive. Conversely, where a relatively weak bond is desired (that is, a high degree of releasability) the residual surface energy of the material should be less than that of the adhesive. These residual surface energies are often times referred to as bonding energies. We have found that the behavior of a film-forming ink can be equated to the behavior of an adhesive, and notwithstanding that the current state of the art in adhesion theory is not well defined and is still in a state of scientific flux, it is our belief that the foregoing is responsible for the effects which permit the successful methods of film formation and transfer without the aid of release agents as herein disclosed.

In accordance with these principles then, at the moment of film transfer the bonding energy between the converted ink film and the carrying pad must be less than the bonding energy between that ink film and the article to be printed. Therefore, in order that these conditions may exist, the residual surface free energy of the carrying pad material must not exceed the residual free surface energy of the article to be printed, and as a practical matter it is preferable that the residual free surface energy of the carrying pad be less than that of the article to be printed.

With this background in mind, reference is now had to the embodiment shown in FIGURE 1 which comprises a drum 10 mounted on shaft 12 for rotation about its axis. A chain 14 and sprocket 16 are provided for rotating the drum in a counter-clockwise direction at the desired rate of speed from any suitable source of power (not shown).

Mounted on the periphery of the drum is an offset surface or pad 18 of material displaying the following characteristics: (a) a totally polymerized material exhibiting a relatively non-adhesive characteristic for the particular ink or fluid film to be employed thereon (i.e. a material having a residual surface free energy which is less than that of the ink film material) and yet be wetted thereby; (b) remains operative over a wide temperature range as dictated by the ink selected; and (c) should preferably be elastomeric in nature. In the preferred embodiment, pad 18 may consist of, but is not limited to, any one of the following materials which exhibit these characteristics in relation to the ink formulations desired to be used; chloroprene; polyvinyl chloride; carboxy methyl cellulose; polytetrafluoroethylene; dimethyl siloxane; polyethylene-propylene; polyester; polyurethane (isocyanate polymer); polyamide; polyisobutylene; butadiene-acrylonitrile copolymer; and polyvinyl alcohol. Positioned adjacent offset surface 18 within the drum is a thermostatically controlled electrical heater 20 conventionally adapted to maintain the temperature of the offset surface 18 at any desired value within the range from room temperature to 400° F. throughout the rotation of the drum 10. Mounted adjacent the periphery of the drum are three separate and independent inking mechanisms 22, 24, 26, each of which comprises an ink reservoir 30, 32, 34, adapted to contain a supply of fluent film-forming printing ink at room temperature (approximately 60° to 90° F.), each ink being a different color, if desired. An ink-applying roll 36, 38, 40, is included in each of the respective inking mechanisms, each roll carrying, in the embodiment shown, a conventional printing plate having

raised type or characters of the desired shape and configuration to which ink is applied from the respective reservoir by means of inking rolls 42, 44, 46, in the usual manner. The fluent layers of ink carried by the respective printing plates are applied successively to offset surface 18 as the drum 10 is rotated to bring the offset surface into contact with the successive printing plates. Each inking mechanism 22, 24, 26, is spaced from the others about the periphery of drum 10 providing a time lag in successive applications of fluent ink from each of the respective mechanisms. Such a time lag permits some degree of change of phase (i.e. film formation) in the applied ink layer before deposition of the next successive ink layer. The final ink-applying mechanism 22, which is the last one from which an ink layer is applied to offset surface 18 as the drum is rotated counter-clockwise, is spaced about the periphery of the drum a predetermined distance from the transfer station 48 at which the ink impression is applied by the offset surface 18 to the surface to be printed.

During the predetermined time interval between the deposit of ink from mechanism 22 and its subsequent transfer from offset pad 18 to the surface printed upon at station 48, certain changes in the physical characteristics of the multiple layered ink film take place. These controlled changes can best be understood by the following explanation. In order to effect a complete transfer of an ink impression, intact, from offset pad 18 to the article being printed without leaving any residual film on the pad, it is necessary as hereinbefore set forth that in its fluent state the ink selected be, among other things, capable of wetting both the offset pad and the article to be printed, but, with a greater affinity for the article being printed than for the offset pad. Accordingly, following final ink deposition from mechanism 22 to heated pad 18, the ensuing film formation reaches a transitory condition whereby two conditions co-exist, namely (1) the cohesive forces within the ink film reach a level which exceeds the adhesive force between the ink film and the offset pad surface, and (2) the adhesive force or bonding energy between the converted ink film and the surface of the article to be printed, when placed in contact therewith, will be of greater magnitude than the adhesion or bonding between the ink film and the offset pad surface. When these film conditions exist, and the film carried by pad 18 is brought into intimate contact with the article to be printed, separation of pad 18 from the article being printed will result in a complete film separation and transfer, intact, from the pad to the article being printed without need for any release agents.

The time interval between the deposit of ink from mechanism 22 and the satisfaction of conditions (1) and (2), above, of course varies with the particular ink composition employed as well as the film thickness and speed of rotation of drum 10. In most instances, with an ink film thickness of 0.1 to 5.0 mils, this time range will vary from $\frac{1}{60}$ to $\frac{1}{5}$ second but may, on some occasions, fall outside this range, especially if a particularly fast or slow setting ink is employed.

The aforementioned increase in cohesive forces can be effected in various ways: for example, in the case of solvent based ink formulations, air-drying at room temperature for a sufficient time or alternatively heating the ink film on the offset pad for correspondingly shorter periods of time, will evaporate the solvents and produce the required degree of phase change; in the case of plastisols or organisol type inks, the use of controlled applications of heat to the ink film will produce the desired results by conversion; in other cases either air drying or heating will result in oxidation, polymerization or other chemical or physical actions to produce the desired results.

With the above concept in mind, we refer again to the drawings and note that in the described embodiment, following the final ink layer application to pad 18 from mechanism 22, heat flow from coils 20 through pad 18

is conducted radially through entire ink layer S producing a transitory film condition defined above, and so alters the physical state of the ink layer that it is converted from its initial fluid condition with little cohesive integrity to a partially dry ink film which exhibits considerable cohesive integrity while attaining substantial adhesive tack on its exposed surface.

Accordingly, it can now be seen that in point of time, the ink film S on offset pad 18 should be transferred to the object to be printed when these above ink film surface conditions exist, to wit, when ink film S becomes a coherent mass, and surface F_2 exhibits sufficient adhesive affinity for the article to be printed to overcome the adhesion between surface F_1 and its carrying pad 18. Therefore, it is at this point of time that the article to be printed, for example, a metal tray 50, is carried by a conventional reciprocating table 52 which is reciprocated in a horizontal plane beneath drum 10 by conventional means, not shown, in timed relation to the rotation of drum 10 so as to bring tray 50 into intimate touching contact with tacky ink film surface F_2 as table 52 moves to the right as shown in the drawing. Upon intimately contacting the surface of the article to be printed, ink film surface F_2 adheres to tray 50 with a force, transmitted through coherent ink mass S, sufficient to overcome the relatively weak adhesive force between surface F_1 and offset pad 18 and thereby completely strips the entire ink film, intact, from the offset pad as tray 50 and pad 18 are separated. Pad 18 is left completely clean without any residual ink film thereon and immediately ready for a subsequent ink application.

Though the preferred embodiment describes our invention in terms of employing an offset pad for purposes of image transfer, it is to be understood that the principles we have set forth operate with equal success in direct printing using any type-face so long as the type surface exhibits the desired characteristics of ink film releasability. For example, metals having a passivated surface exhibit low residual surface energies due to such oxide coatings, hence function well as carrying surfaces in achieving results of complete and intact ink film transfer to the article being printed. As another and further example, we have found that virteous surfaces, e.g. glass, serve very successfully as film carriers and exhibit good film releasability.

Though the selected image carrying surface (either an offset pad or selected type face) should be sufficiently smooth so as not to introduce any deleterious effects of mechanical bonding with the ink film, it has been found that smooth surface irregularities on such an image carrying member do not appreciably effect the release characteristics and in turn impart a textured pattern on the exposed surface of the transferred film. Such texturing provides a three dimensional appearance to the image which may be highly desirable, particularly if the transferred image is of a decorative character.

We have previously indicated that the offset pad or other film carrying surface should preferably exhibit a low level of residual surface energy, as for example, a totally polymerized surface, in order to effect the film release characteristics required by our process. Accordingly, once the residual surface energy of the film carrying surface begins to increase, as for example, by depolymerization, the carrying surface must be restored or replaced. Such surface degradation may be caused by the heat from coils 20 or from active reagents in the inks employed.

The nature of the ink employed for any specific application will be determined by the relative residual surface energies between the article to be printed and the offset pad material, the speed at which the printing operation is to be performed and other printing requirements.

The complete removal of the ink film from the offset surface ensures that each subsequent ink impression will be clear and free from irregular or blurred edges. It also makes possible the printing of multicolored designs by overcoming the need for close register of colors because it is possible to position impressions of different

colors so that a portion of each successive impression overlies at least a portion of previous impressions on the offset surface. The very thick natures of each ink impression made according to the present invention and the subsequent high color density thus make possible multi-colored images without the necessity for precise registration of separate impressions.

Furthermore, complete removal of the ink film or films from the heated offset surface at the transfer station 48 not only makes it possible to apply a different ink design on each successive printing operation, as for example, in printing a series of articles with sequential numbers with an automatic indexing head, without blurring or obscuring the impressions, but in addition makes possible a great color density of each print. Indeed, if desired, the thickness of the film of ink in the impression can be increased by providing identical printing rolls and colors of ink in two or more successive ink-applying mechanisms, the successive ink impressions being truly additive. In such a case, when the accumulated thick deposit of ink upon the heated offset surface is brought into intimate contact against the surface of the article to be printed, the entire deposit is completely transferred intact from the offset surface to the surface to be printed as a very dense film of unusual thickness which is for all practical purposes immediately dry.

Though the surface to be printed will generally be at room temperature, our process does not necessarily require this condition and printing may be accomplished at elevated temperatures above room temperature so long as the temperature of the article being printed is below the liquifying temperature of the particular ink employed so as to preserve cohesive integrity of the film.

Similarly, our process can be carried out at below room temperatures so long as the surface to be printed remains dry and uncontaminated by moisture condensate, thereby-permitting a good adhesive bond between the ink film and the surface.

In view of the foregoing, it now becomes apparent that the process described depends on the control and interrelation of a combination of factors which includes any one or more of the following: temperature of the film carrying surface; temperature of the article being printed; cohesiveness within the ink film; the relative residual surface energies between the film carrier pad material and the article to which the film is to be transferred; wetting ability and polarity of the ink; ink viscosity, plasticity, miscibility, and solvent content; time of exposure on and temperature of the heated offset pad; and ink formulations themselves. The foregoing is not intended to be exclusive of other factors, but is merely representative of the factors involved.

It is to be noted that contrary to current state of the art printing techniques, the herein disclosed invention requires no excessive contact pressure of image film against the article being printed; only an intimate surface contact sufficient to permit adhesion between image and article is necessary.

The following combinations of film carrier pad, ink, receptor surface, and temperatures are typical examples of those which may be employed in the present invention, but it will be understood that there are other combinations which may be equally satisfactory.

Example 1

Ink ingredients:	Percent (by weight)
Cellulose acetate	10-20
Gamma butyrolactone	60-80
Carbon black	10-15

The above ink formulation when deposited in a layer of 0.1 to 5.0 mils on a carrier surface of chloroprene maintained at 200° F. for approximately 1/10 to 1/2 second will transfer in accordance with the principles herein disclosed on receptor surfaces of polystyrene, Delrin, cellulose acetate, glass, brass, copper, chromium plate, vinyl and paper.

When employed in conjunction with a carrier surface of either polyvinyl alcohol or carboxy methyl cellulose maintained at 150° F., complete film transfer can be accomplished to receptor surfaces of paper, vinyl, and Delrin.

As an example of using direct printing type face in accordance with these disclosed principles, such type face if composed of polytetrafluoroethylene or chromium plate and maintained at 200° F. will transfer the above ink to receptor surfaces of polystyrene, paper, vinyl, and cellulose acetate.

Example 2

Ink ingredients:	Percent (by weight)
Maleic resin	10-20
Nitrocellulose (1/2 sec. type)	5-15
Diethylene glycol ethyl ether	20-40
Vinyl chloride—dispersion resin	10-15
Titanium dioxide	30-40
Phthalocyanine blue	4-6

This ink formulation when deposited in a resultant layer of 0.1 to 5.0 mils thick on a carrier surface of polyisobutylene maintained at 250° F. for approximately 1/10 to 1/2 second, will transfer intact to polystyrene and paper.

A carrier surface of polytetrafluoroethylene at 200° F. will transfer this ink film well to polystyrene.

A carrier of chloroprene at 225° F. will transfer such a film intact to polystyrene.

Example 3

Ink ingredients:	Percent (by weight)
Vinyl toluene-butadiene copolymer	20-30
Diethylene glycol ethyl ether	45-50
Toluidine toner	10-15
Lithol toner	1-3
Titanium dioxide	5-10

This formulation when deposited in a layer of 0.1 to 5.0 mils thick on a carrier surface of butadiene-acrylonitrile copolymer maintained at 200° F. for approximately 1/10 to 1/2 second will transfer intact to a polystyrene surface.

Example 4

Ink ingredients:	Percent (by weight)
Vinyl chloride-vinyl acetate copolymer	40-45
Plasticizer	40-45
Stabilizer (barium type)	1-2
Stabilizer (cadmium type)	1-2
Titanium dioxide	10-20

This formulation when deposited in a layer of 0.1 to 5.0 mils thick on a carrier surface of chloroprene maintained at 325° F. for approximately 1/10 to 1/2 second, will transfer intact to surfaces of polystyrene, paper, Delrin, and vinyl.

Example 5

Ink ingredients:	Percent (by weight)
Isophorone	50-60
Vinyl chloride-vinyl acetate copolymer	15-20
Oil based extender	5
Dimethyl phthalate	5-15
Carbon black	10

This formulation when deposited in a layer of 0.1 to 5.0 mils thick on a dimethyl siloxane carrier surface maintained at 275° F. for approximately 1/10 to 1/2 second will transfer intact to surfaces of paper and vinyl.

The present invention provides a method and apparatus of great flexibility and adaptability for printing a variety of articles inasmuch as the temperature of the inking mechanism and ink itself, as well as the offset surface can be varied over a considerable range above and below room temperature and the time interval during which the ink impression is maintained on the offset surface can also be varied over a considerable range, either by increasing the size of the drum, decreasing the speed of rotation, or changing the spacing between the ink-applying mechanism and the printing station about the pe-

riphery of the drum. In connection with maintaining the offset pad below room temperature, there may be applications in which extremely quick-setting inks would be useful. Certain of these inks can be compounded so that they "set" or "dry" extremely rapidly at room temperature. Accordingly, an offset pad maintained at below room temperature would control this action and thereby permit the ink to be employed in accordance with the herein disclosed principles. For example, we have actually demonstrated that by means of so-called thermoelectric effects or other similar effects, the ink reservoir and its associated printing plates may be economically maintained over a wide range of temperatures substantially below room temperature which will maintain the ink on the inking mechanism at an equivalently low temperature. The numerous variable factors make it possible to employ a wide variety of film forming inks which may be especially tailored for application to particular surfaces.

It is to be expressly understood that an ink may be presented to the printing plates or offset pad in states other than being fluent, for example, such inks could be in a solid or powder form equally as well, and so long as the image attained the desired conditions at moment of transfer as hereinbefore set forth, it will transfer in accordance with these principles. It is to be further understood that the ink formulations employed in the practice of this invention do not depend upon the use of so-called release agents or parting compounds. Should any of the ink ingredients disclosed in the numerous examples be regarded as exhibiting such characteristics, they are included for other reasons, but not as parting compounds.

Thus it can be readily seen that we have achieved our objectives in developing a high-speed process and apparatus which provides an immediately dry multi-color print. Moreover, we have disclosed a novel method whereby the film forming ink impression on the offset pad or type face is so completely transferred that no residual ink film remains to impair subsequent printing operations. By virtue of these distinct advantages, it becomes possible as hereinbefore mentioned to mount an automatic indexing head in conjunction with the ink applying mechanisms and thereby consecutively number articles being printed without interrupting the cyclic operation of the process.

Though we have particularly described our invention in terms of its application to offset printing, it is to be understood that this is merely illustrative of the broader invention, namely, a method and apparatus for the formation of a film and its subsequent intact transfer, without the aid of any release agent, to a selected surface.

It will be understood that various changes in the details, materials, setups and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims. We claim:

1. A method of forming an integrated film and transferring such a film intact from its carrying surface leaving no film residue thereon, to another surface comprising the steps of: providing a supply of fluid film-forming material having a first level of residual surface energy; depositing a layer of such film-forming material upon a carrying surface, said carrying surface exhibiting a second level of residual surface energy which is less than that of the layer of film forming material; heating the fluid layer of material to alter the physical state thereof so as to increase its cohesive integrity to a magnitude in excess of the bonding energies between the layer of film forming material and said carrying surface, while concurrently maintaining tack on the exposed film surface; bringing into intimate contact the exposed tacky surface of the film on the carrying surface with a film

receptor surface, said receptor surface exhibiting a third level of residual surface energy in excess of that of the exposed tacky surface of the film; and separating said film carrying surface from said film receptor surface whereupon because of the energies involved said film is completely transferred from said carrying surface as an integral mass adhering intact to said receptor surface.

2. The process set forth in claim 1 wherein said carrying surface consists of an elastomer selected from the group consisting of chloroprene, polyvinyl chloride, carboxy methyl cellulose, polytetrafluoroethylene, polymerized dimethylsiloxane, polymerized ethylene-propylene, polyester, urethane (isocyanate) polymer, polyamide, polyisobutylene, butadiene-acrylonitrile copolymer, and polyvinyl alcohol.

3. A method of forming and transferring a continuous and completely integrated multi-layer film comprising the steps of: providing a supply of fluid solution film-forming materials at room temperature exhibiting a first residual surface energy level; continuously depositing a plurality of successive layers of said film-forming materials which overlay one another at least in part upon a continuously moving, smooth, totally polymerized carrying surface exhibiting a second residual surface energy level, said second residual surface energy level being less than said first residual surface energy level; increasing the cohesive integrity and viscosity of the composite layer to a magnitude in excess of the interface bonding energies between the composite layer and said carrying surface while concurrently maintaining tack on the exposed surface of the composite film; pressing into intimate contact the exposed surface of the composite film with a continuous moving film receptor surface, said receptor surface exhibiting a third residual surface energy level which is in excess of the first residual surface energy level of the fluent film forming material; and separating said carrying surface from said receptor surface, such separation adapted to cause a complete interfacial separation between said carrying surface and said film.

4. The method of printing wherein the inked image is completely transferred intact from the printing element to the surface being printed, which comprises the steps of: providing a fluid supply of film-forming ink exhibiting a first residual surface energy level; applying a layer of said fluid ink to a heated, polymerized elastomeric offset heating pad exhibiting a second residual surface energy level, said second energy level being lower than the first; converting the fluid ink layer so as to increase the cohesive forces within the ink layer to a level of magnitude in excess of the bonding energies between the ink layer and the offset pad, while concurrently attaining a tacky condition on the exposed surface of the ink layer; bringing into intimate contact the tacky exposed surface of said ink film with the surface to be printed, said surface exhibiting a third residual surface energy in excess of that of the exposed tacky surface of the film; and separating said offset pad from said latter surface to completely transfer the ink film intact from the offset pad to the surface being printed as an integral mass.

5. The method of multi-color offset printing comprising the steps of: depositing successive impressions of different colored film-forming inks having a first viscosity level, and a first residual surface energy level so that a portion of each successive ink impression overlies at least a portion of the previous ink impression, upon an offset surface exhibiting second residual surface energy level which is less than the first level; providing a time lag between the successive impressions to increase the ink viscosity of the previous impression to a second viscosity level sufficient to prevent comingling of the colors with the succeeding impression; continuing to increase the cohesive integrity and viscosity of the composite ink impression to a magnitude in excess of the bonding energies between the composite impression, and the offset

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surface, while preserving tack on the exposed surface of the ink impression; bringing into intimate contact the exposed tacky surface of the impression with the surface to be printed, said surface exhibiting a third residual surface energy level which is in excess of that of the exposed tacky surface of the composite film; and separating the offset pad from the surface being printed whereby to transfer the ink impression in its entirety from the offset pad intact as an integral mass to the surface being printed.

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DAVID KLEIN, *Primary Examiner.*
ROBERT E. PULFREY, E. S. BÜRR,

Assistant Examiners.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,255,695

June 14, 1966

Carl R. Johnson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, lines 48 and 49, for "highly adhesive" read -- highly abhesive --; column 6, line 43, for "virteous" read -- vitreous --.

Signed and sealed this 22nd day of August 1967.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents