Patented Aug. 10, 1943 2,326,321

UNITED STATES PATENT OFFICE

2,326,321

METHOD OF MULTICOLOR PRINTING AND INK THEREFOR

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No Drawing. Application August 1, 1940, Serial No. 349,307

11 Claims. (Cl. 101—211)

This invention relates to a method of printing, and more particularly to a method of printing in which a plurality of colored inks is used, and heat is applied to dry the printed surface immediately after printing.

An object of the invention is to produce a multi-color printed impression of superior clarity and brilliance.

Another object is to utilize a printing process of the character described, by which blurring and smudging of the ink after printing is eliminated.

A further object is to print with a series of inks which exhibit good mutual adhesion in the order applied, and which will become dry in substantially the same total elapsed time under the application of heat.

In printing in several colors on high speed letter presses, it is the practice to apply each colored ink successively to the paper, in superposed relation. The colors may be applied in any desired order, but in general, yellow is printed first, followed by red, then blue, and lastly by black.

In order that clean cut impressions of each successive color may be obtained, the ink already applied must have sufficient body viscosity and "tack" to cause the following color to adhere firmly thereto, causing the complete and uniform release of the subsequent ink from the printing plate, and its superposition onto the printed medium. Such adhesion of one printed impression for another is called "trapping," and is effected by regulating the body and tack of the superposed inks so that the first to be applied is the most tacky, followed by others of intermediate tackiness, and lastly by the least tacky member, each successive ink being less tacky or viscous than the one just previously applied. If this sequence is not followed, or if it is disrupted by some outside force, the ink on the printing plate, instead of releasing its hold on the plate, and adhering to the previously deposited ink film, retains its adhesion to the plate and pulls away the film of ink already deposited on the paper. This difficulty may occur to greater or less extent and is described as poor trapping.

The regulation of tack and body to insure efficient trapping, has led to other undesirable results in the field of "heat dry" inks. Heating is not begun until all the color impressions have been applied, and the printed subject is complete. This means that although all the colors are wet when heating is commenced—those nearest the top are also of a relatively thin, low viscosity character, and contain a larger amount of solvent than do the lower colors. When the print is exposed to the high degree of heat required to dry the entire impression in a fraction of a second, the viscosity of the upper layers is reduced still further, so that the ink tends to run and spread, away from the original half tone dots as applied, and merging with others, create a dirty, blurred and smudged appearance on a print originally perfectly printed.

I have now discovered that this spreading difficulty can be overcome by the proper compounding and application of a series of different colored inks relatively to each other, while retaining the desired tack and viscosity differences, but adjusting the relative evaporation rates of the inks so that under final drying, all will dry in substantially the same elapsed time regardless of their variations in viscosity and solvent content.

The different pigments used to produce the different colored inks have varying characteristics of specific gravity, oil absorption, opacity and the like. This in turn requires the use of different amounts of the individual pigments to obtain the degree of color strength and hiding power necessary as well as proper body and tack. Thus a much larger percentage of chrome yellow pigment is necessary for a good yellow ink, than is required of black for a good black ink. The remainder of the ink is made up of vehicle, which, in the case of "heat dry" inks consists chiefly of resins and solvents in fixed proportions. Thus a yellow ink—which contains more pigment—will necessarily contain less vehicle, therefore less solvent, and will be more viscous. This fortuitous requirement of the yellow pigment is one of the reasons why it is generally printed first, that is, because it is easier to make a satisfactory, highly tacky yellow than blue or black. A black ink, on the other hand, requires a relatively much smaller proportion of pigment to obtain the required intensity, hence contains more vehicle, and hence more solvent, and is less tacky than the yellow.

Inks which contain as low a percentage of solvent as do the yellow and red, must necessarily use a solvent with a very high boiling point, i. e. a low evaporation rate—one which will not evaporate to any appreciable extent during manipulation on the distributing rolls and operation of the press, because even the slightest evaporation increases the viscosity so appreciably at this high concentration, that hardening and caking of the ink on the rolls will take place. But when a similar high boiling solvent is used for the subsequent

impressions, it must be used in such large quantities, that for these inks its slow evaporation is no longer an asset, but a detriment, for—as pointed out above—spreading occurs before sufficient solvent is evaporated to retard the flowing properties and set the ink.

Table I will illustrate a series of inks showing in round numbers the differences in the various main ingredients and characteristics of inks adapted for four color superposed printing.

TABLE I

Pigment	Pigment	Vehicle [1]	Solvent	State
	Per cent	*Per cent*	*Per cent*	
Yellow	50	50	25	Very tacky.
Red	40	60	30	Less tacky.
Blue	30	70	35	Much less tacky.
Black	20	80	40	Very fluid.

[1] Vehicle contains approximately equal parts binder and solvent.

Table I indicates clearly the situation caused by the necessity of adjusting the multi-colored inks to the exigencies of the "trapping" requirement. The top impressions, with their much higher solvent, and much lower pigment content, are much more fluid than the earlier ones. The inks are applied as half tone dots, and the sharpness and clarity of the prints depend on these dots remaining in the exact position and size printed. When, however, the very fluid top layers are first subjected to heat, the viscosity of the ink is so reduced that the ink begins to flow and spread, and this spreading proceeds to a degree sufficient to cause serious blurring before the ink can be congealed by the evaporation of enough solvent to set and harden it.

I have found that if my several inks are compounded with solvents having evaporation rates varying inversely with the tack of the ink, and inversely with the pigment content, the impressions can all be made to dry and harden simultaneously and rapidly enough to entirely eliminate any difficulty with spreading of the dots of the top layers. Thus my first impression inks, which are very heavy and tacky, containing large proportions of pigment, and in which a relatively small proportion of solvent is present, will contain a solvent of relatively high boiling point, i. e., low evaporation rate; the next ink to be printed, containing more solvent, and less pigment, will contain a solvent of somewhat lower boiling point; the later colors, of still higher solvent content, and still lower pigment content, will contain solvents of still lower boiling points, to compensate for the greater quantity present to be evaporated.

Table II shows a series of inks similar to those shown in Table I, containing solvents of varying boiling points depending on the tack of the ink, and the order in which the inks are to be printed.

TABLE II

Color	Solvent	Pigment	Approximate boiling range of solvent
	Per cent	*Per cent*	°C.
Yellow	25	50	300-310
Red	30	40	280-290
Blue	35	30	260-270
Black	40	20	250-260

Typical formulas of the individual inks in the series are given below:

Yellow ink (printed first)

	Parts by weight
Solvent (B. R. 300–310° C.)	17.5
Resin	17.5
Yellow pigment (equal parts lemon yellow and phosphate yellow	56.0
Alumina hydrate	4.0
Linseed oil	5.0
	100.0

Red ink (printed second)

	Parts by weight
Solvent (B. R. 280–290° C.)	29
Red pigment (Dark Lithol Red)	37
Alumina hydrate	5
Resin	29
	100.0

Blue ink (printed third)

	Parts by weight
Solvent (B. R. 260–270° C.)	33
Resin	28
Blue pigment (Peacock 35, Milori 4)	39
	100.0

Black ink (printed last)

	Parts by weight
Solvent (B. R. 250–260° C.)	40
Resin	34
Carbon black	17
Reflex blue paste	9
	100.0

The solvents used in the illustrations above are petroleum fractions having the indicated boiling ranges, the resin is a blended mixture of a rosin modified phenol aldehyde resin known in the trade as Beckacite 1116, and a zincated rosin. In the case of the yellow ink, these resins are blended in the proportions of about 2 parts of the modified phenol resin to 1 part of the zincated rosin, while in the other colors, the proportions are approximately equal. Other resins suitable for use in my inks are ester gum modified phenol resins such as Beckacite 1112, or similar resins modified with maleic acid instead of with ester gum. Phenylated copals, typified by Beckopol 1400, can also be used. Cumar and alkyd resins, as well as certain natural resins such as dammar, produce very satisfactory inks when blended with other resins such as rosin, ester gum, limed or zincated rosins.

In preparing my series of inks for multi-color superposed printing, I prefer to use petroleum solvents having boiling ranges varying by at least about ten degrees centrigrade from each other. This is not absolutely necessary, however, as smaller variations will often give satisfactory solvent release on eventual drying. Larger differences, however, are desirable, and should be used where possible, but the ten degree spread, or even less, appears to produce greatly improved results so as to be satisfactory under many conditions of use. The resins are added gradually to the heated solvent at about 240° F., and stirred continuously until a homogeneous mass is produced. To the varnish thus produced the desired quantity of pigment is added under constant agitation until the varnish has taken up the color, whereupon the mass is ground on a suitable mill such as an ink mill until adequate dispersion is obtained.

After all the colors have been printed, the sheet is immediately subjected to very high temperatures—in the order of 250° C. and higher—to dry the ink in a fraction of a second. And as is stated above this heat necesary for very rapid evaporation, which rapidly decreases the viscosity and correspondingly increases the tendency to flow and spread in an irregular and uncontrolled manner, likewise tends to decrease the viscosity of the binder and so to make the ink more fluent for a given solvent content and therefore tends greatly to increase this irregular or uncontrolled spread, which tendency likewise is increased where similar solvents which are miscible are used. But by properly decreasing the boiling ranges of the solvents for successively imprinted inks of the series the rate of evaporation may be so increased that despite the larger amount of solvent the viscosity may be maintained within the desired limits and the undesirable spread of one superposed ink on that one below may be kept within controlled limits as described so that blurring, etc. will be avoided. Although the top layer, as printed according to my invention still has the same quantity of solvent as did the prior art inks, its evaporation rate is so much faster, that now the heat causes such rapid evaporation that the upper layers do not have time to spread before they are set and fixed in the positions imposed by the half tone dots, and thus a clear, sharp, brilliant print is produced.

Although a four color process has been used to illustrate my invention, the method may be applied to a process utilizing fewer colors or to one in which a greater number are used. Five color processes are common, and sometimes even more are used to obtain special effects. In addition to the usual pigmented colors, various shades of metallic inks, silver or gold colors, or various shades with metallic sheen are often separately applied. In such cases, the successive inks will be compounded to have the necessary tack to achieve "trapping" in the order in which they are printed, and the boiling point of its solvent will be adjusted as described, to its position in the printed series.

In the examples given, the successive inks have contained successively decreasing amounts of pigment, and a more or less correspondingly increased amount of solvent. While this condition is usual, it is not essential as the colors can be printed in a progression independent of the pigment content, provided the tack is adjusted by using a higher viscosity binder material, or by other means. Thus in printing on transparent material such as Cellophane and the like, in which the print is to be viewed from the reverse side, it is usual to print in an order opposite to that described in the illustrations, namely in the order—black, blue, red, yellow, instead of yellow, red, blue and black. Likewise, in many instances, in four color printing, the blue is applied last, that is, after the black, and quite often the relative positions of the yellow and red are reversed.

While the above sets forth a preferred embodiment of the practicing of my invention, it is to be understood that departures may be made therefrom within the scope of the invention as described and claimed.

What is claimed is:

1. Method of multi-color printing, which comprises successively printing in contiguous relation a series of printing inks having progressively decreasing tack and a decreasing proportion of pigment, each ink containing a larger proportion of solvent which is of a predetermined higher evaporation rate than the preceding ink, said solvents all being of similar organic composition.

2. Method of multi-color printing, which comprises successively printing in contiguous relation a series of printing inks having progressively decreasing tack and a decreasing proportion of pigment, each ink containing a larger proportion of solvent which is of a predetermined higher evaporation rate than the preceding ink, said solvents all being of similar organic composition, and heating to set the ink.

3. Method of multi-color printing which comprises printing in succession a series of inks having progressively decreasing tack and progressively increasing solvent content, said solvent in each successive ink having a boiling range lower by a controlled amount than the preceding ink, said lower boiling range being proportioned to the larger amount of solvent present in each successive ink, and all solvents having boiling ranges between the limits of about 250° C. and 310° C.

4. A method of printing in multi-color, in which the printed impression is dried by the application of heat immediately after printing, which comprises printing successively with a plurality of printing inks of successively decreasing tack and successively increasing solvent content, said solvents having successively lower boiling ranges, the boiling range in each successive ink applied being controlled to be inversely proportional to the amount of solvent to give a generally constant evaporation rate for each successive ink.

5. Method of multi-color printing which comprises printing in succession with a series of inks having successively decreasing tack, successively decreasing pigment content, and successively increasing solvent content, the solvent in each successive ink varying in boiling range from the preceding ink by a negative increment of about 10° C.

6. Method of four color printing which comprises printing in succession with; an ink comprising a solid component and a solvent, said solvent comprising about 25% of said ink, and having a boiling range of approximately 300–310° C.; an ink comprising a solid component and a solvent, said solvent comprising about 30% of said ink and having a boiling range of approximately 280–290° C.; an ink comprising a solid component and a solvent, said solvent comprising about 35% of said ink, and having a boiling range of approximately 260–270° C.; and an ink comprising a solid component and a solvent, said solvent comprising about 40% of said ink, and having a boiling range of approximately 250–260° C.

7. Method of multi-color printing which comprises printing first with an ink of high tack and low solvent content in which the solvent has a relatively high boiling range of the order of 300–310° C.; second with an ink of lower tack and higher solvent content, which solvent has a relatively lower boiling range of the order of 280–290° C.; third, with an ink of still lower tack and still higher solvent content, said solvent having a boiling range lower than that of the preceding ink, and in the order of 260–270° C.; fourth with an ink of still lower tack and higher solvent content than the preceding ink, said sol-

vent having a boiling range relatively lower than that of the preceding ink and in the order of 250–260° C.; and subjecting the printed impression to temperatures of the order of 250° C. to dry and set the ink.

8. Multi-color printing ink adapted to be printed in a succession of impressions with each impression trapped on the sheet and all of the impressions being capable of drying rapidly under heat within a period of time sufficiently short to avoid running and spreading of any of the impressions consisting of a series of printing inks each of predetermined characteristics with respect to the adjoining ink of the sequence and each comprising a vehicle, a pigment and a solvent, the several inks of the series each containing an amount of pigment less than the one preceding it and more than the one succeeding it in sequential printing, and said solvent component of each ink being present in quantity inversely proportional to the pigment content and the boiling range of said solvent varying directly as the pigment content, whereby the sequentially printed inks have a predetermined coordinated rate of drying.

9. Multi-color printing ink adapted to be printed in a succession of impressions with each impression trapped on the sheet and all of the impressions being capable of drying rapidly under heat within a period of time sufficiently short to avoid running and spreading of any of the impressions comprising a series of pigment-vehicle-solvent mixtures forming the successive impressions in which the proportions of pigment, the tacky qualities, and the boiling point of the solvents vary inversely with the order in which the impressions are made and with the proportion of solvent varying directly therewith.

10. Multi-color printing ink adapted to be printed in a succession of impressions with each impression trapped on the sheet and all of the impressions being capable of drying rapidly under heat within a period of time sufficiently short to avoid running and spreading of any of the impressions comprising a series of pigment-vehicle-solvent mixtures forming the successive impressions in which the proportions of pigment, the tacky qualities, and the boiling point of the solvents vary inversely with the order in which the impressions are made and with the proportion of solvent varying directly therewith, the solvent in each successive ink varying in boiling range from the preceding ink by a negative increment of about 10° C.

11. Multi-color printing ink adapted to be printed in a succession of impressions with each impression trapped on the sheet and all of the impressions being capable of drying rapidly under heat within a period of time sufficiently short to avoid running and spreading of any of the impressions including a series of four printing inks adapted for use in multicolor printing in a predetermined sequence in which the ink first to be printed contains approximately 50% pigment; 25% binder and 25% solvent; the second ink to be printed, contains approximately 40% pigment, 30% binder and 30% solvent; the third ink contains approximately 30% pigment, 35% binder and 35% solvent; the fourth ink contains approximately 20% pigment, 40% binder and 40% solvent; and in which the general character of the solvent in each successive ink is similar in kind, and varies in boiling range by increments of about 10° C. between the limits of about 310° C. for the first printed ink, to about 250° C. for the last printed ink.

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