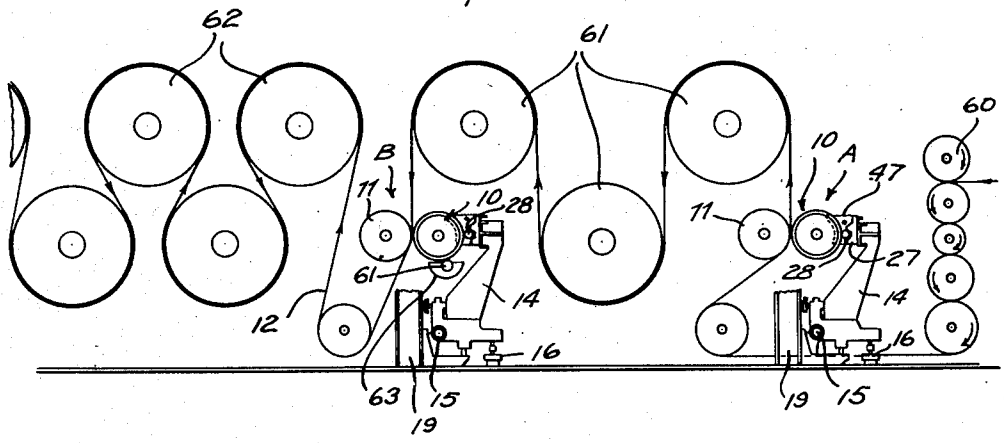
July 17, 1951 G. HAYWOOD ET AL 2,560,572

METHOD OF COATING PAPER

Filed June 25, 1946 3 Sheets-Sheet 1

Fig. 1.



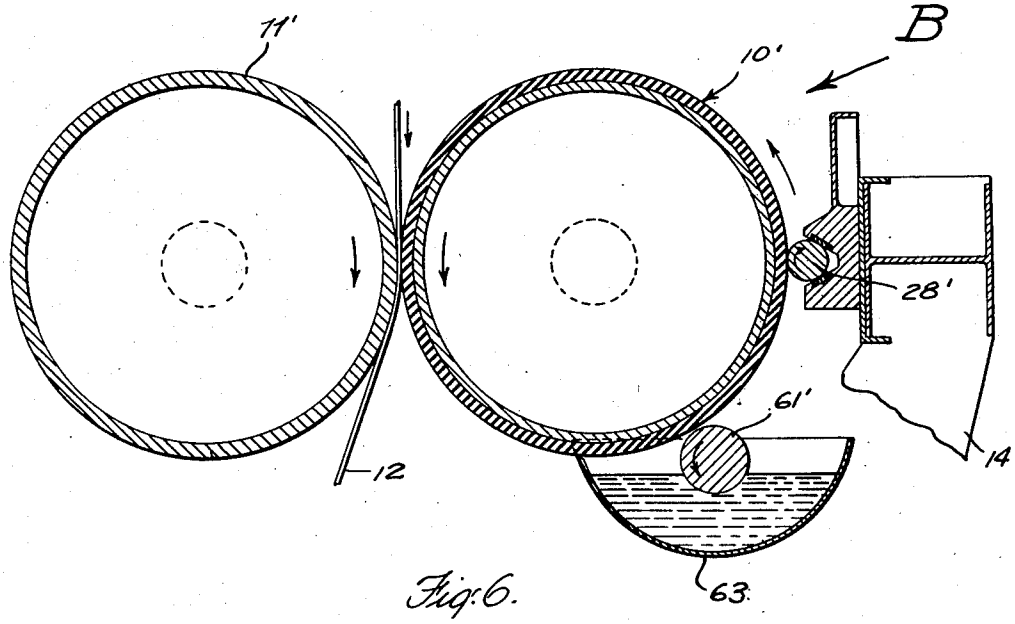


Fig. 6.

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METHOD OF COATING PAPER

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Fig. 2.

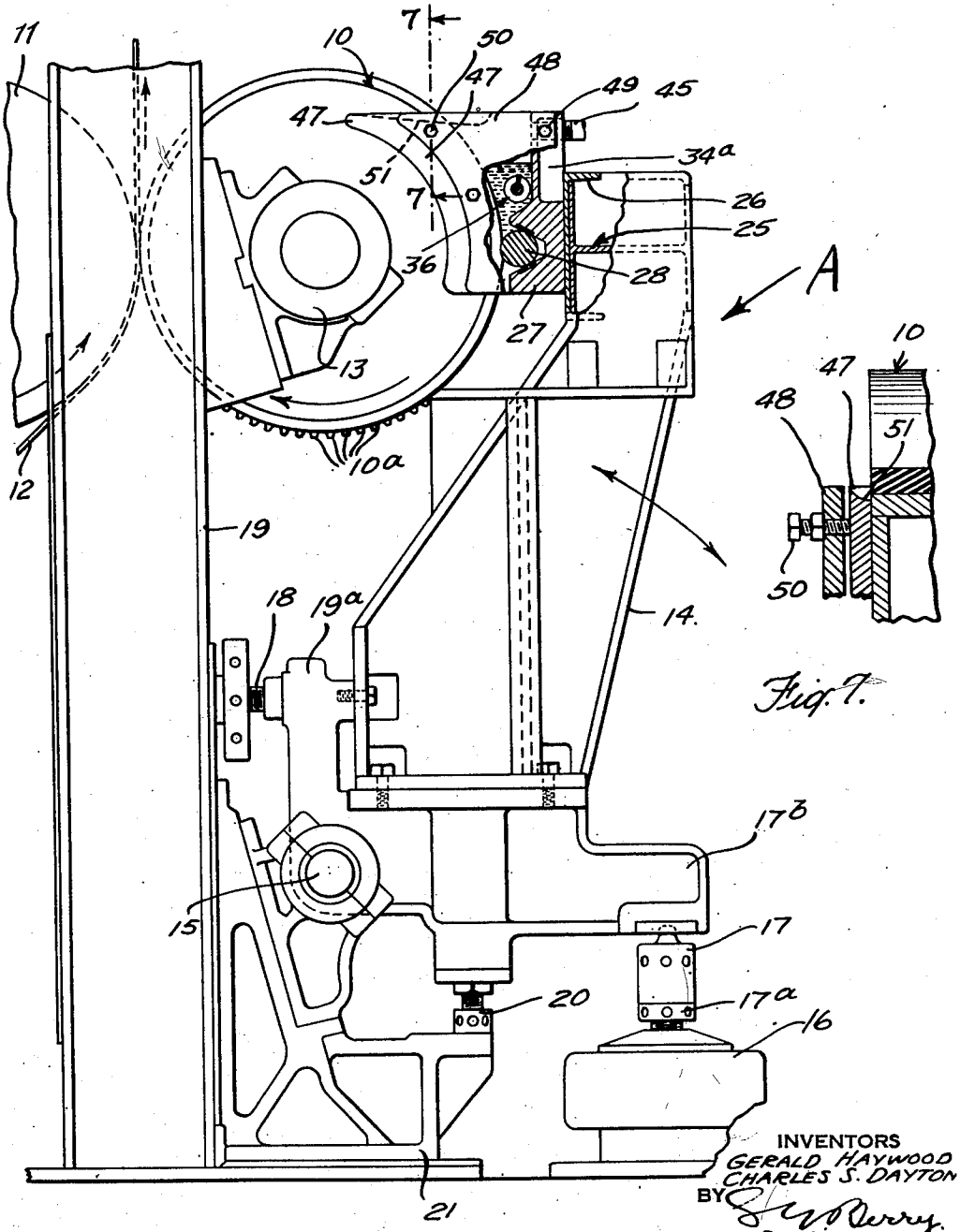


Fig. 7.

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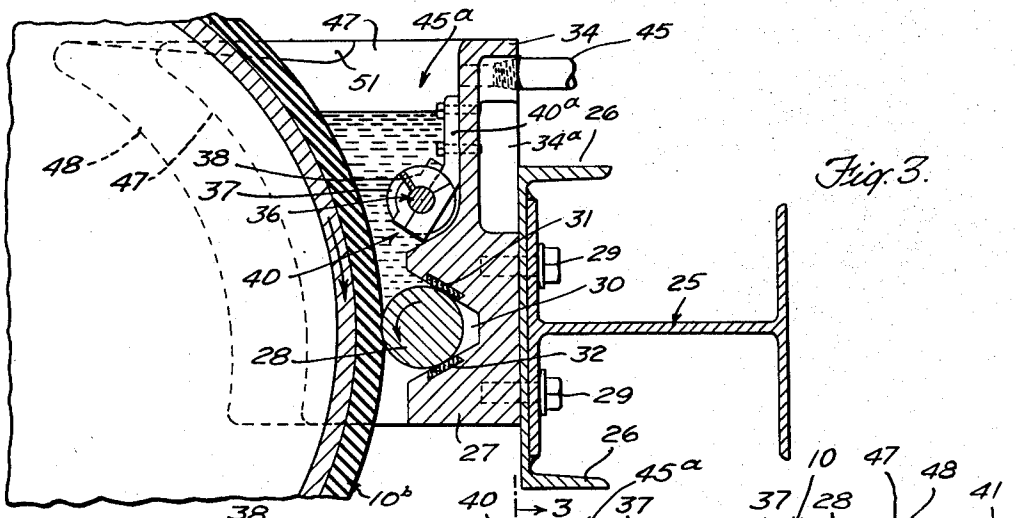


Fig. 3.

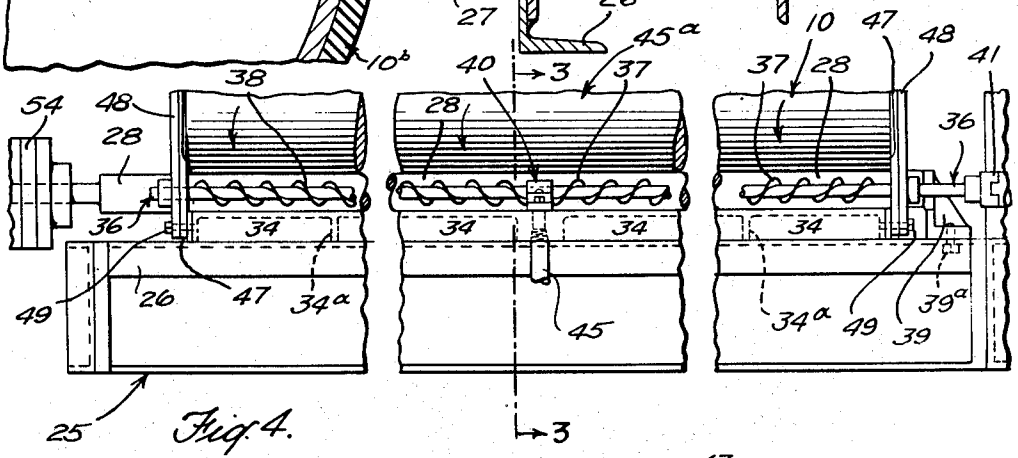


Fig. 4.

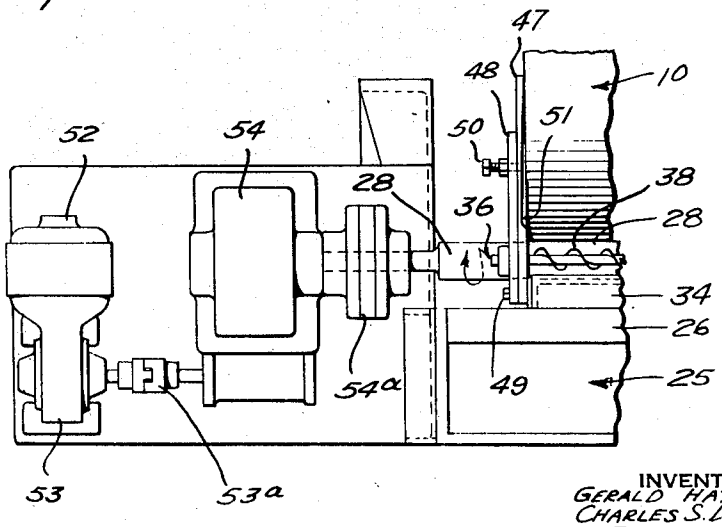


Fig. 5

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2,560,572

METHOD OF COATING PAPER

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Application June 25, 1946, Serial No. 679,240

3 Claims. (Cl. 117—111)

1

Our present invention relates to a method of coating paper.

This application is a continuation in-part of application Serial Number 425,948 filed January 8, 1942, now abandoned.

The main object of our invention is to provide an improved method of coating on the Fourdrinier machine (so called machine coating), although the invention may be availed of for coating separately of the Fourdrinier if this is desired. The invention has special reference to the manufacture of coated paper of the type suitable for book and magazine purposes.

In coating on the Fourdrinier machine many problems arise which are not present when coating is conducted without reference to the Fourdrinier. The foremost of such problems is the adaptation of the coater to existing paper making machines, since the conditions of available space, of width of web and speed of coating are already fixed.

Because of the limitations of space, and also because such driers are already available, the coated web must be dried on the Fourdrinier drum driers, and therefore the color must harden or "set" in a smooth film immediately upon being applied, in order that the so coated web may be handled by the regular drier drums without the color becoming smeared and without distortion or wrinkling of the sheet due to the absorption of moisture from the coating. In order to realize these objects it is necessary, inter alia, to take advantage of the thixotropic property of certain colors. By thixotropy is meant the property which certain fluid bodies possess of becoming less viscous when mechanical work is performed upon them, as when subject to shearing stresses, for example. Thus many clays are thixotropic, although some exhibit the reverse property of being dilatant, i. e., they become more viscous when work is done on them.

To thus take advantage of the thixotropic properties of the color we apply the same between a pair of cylindrical surfaces one of which is deformable to a limited degree and the other of which is non-yielding, substantially rigid and of smaller radius of curvature so as to create an enlarged contact zone between the two surfaces wherein the color is subjected to shear, thus delivering from between the surfaces a film of the color of uniform thickness and reduced viscosity, which is then applied to the base stock, the so applied color "setting" immediately because of the removal of the shearing force, aided also by the abstraction of water from the color by the base stock.

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It is a further feature of our invention to carry out the initial drying of the freshly coated sheet in a manner to prevent too fast removal of the moisture therein by subjecting the freshly coated sheet to slow drying before the sheet is passed into the regular drying section of the Fourdrinier. We have found this is carried out best by passing the freshly coated sheet around one or more drying drums which are only moderately heated, say under 170° F., whereby the sheet is partially dried while permitting the necessary time element for absorption and expansion before the fibers are set by drastic drying such as would result were the freshly coated sheet to be passed around drying rolls heated to the usual temperature above 212° F. It is also a further feature properly to condition the base stock so as to result in the coating remaining on the surface of the sheet rather than penetrating the same and mingling with the fibers of the base sheet. To achieve this, the base stock desirably is smoothed or calendered prior to the coating operation.

In a preferred embodiment of our invention we coat but one side of the paper at a time, the coating being superficially dry before the reverse side of the paper is coated. In this way the least amount of water absorption by the base sheet results whereby a minimum distortion is had.

For a more complete understanding of our invention reference may now be had to the following detailed description taken with the annexed drawings in which:

Fig. 1 shows apparatus for carrying out our improved process;

Fig. 2 is an enlarged view in vertical elevation partly in section showing details of the coating device and the mounting thereof;

Fig. 3 is an enlarged view in vertical section of a portion of the device showing the doctor roll and a portion of the transfer roll, the section being taken on line 3—3 of Fig. 4;

Fig. 4 is a plan view of the right hand portion of the machine as seen in Fig. 3;

Fig. 5 is an enlarged view showing the drive of the doctor bar;

Fig. 6 is a sectional view showing application of the coating to the felt side of the sheet; and

Fig. 7 is a fragmentary sectional detail view taken on line 7, 7 of Fig. 2.

Referring to the above mentioned figures, and more particularly to Figures 2 and 3, 10 denotes the applicator or transfer roll, 11 the backing roll, and 12 the paper web passing between the two rolls 10 and 11. Roll 10 is shown as journaled in journal 13, said rolls 10 and 11, which de-

sirably have substantially the same surface speed. being driven in known manner by means which includes gear 10a, Fig. 2. The coating device proper is mounted in a frame 14 which in turn is mounted for ajustment of the coating device with respect to the roll 10. Thus the frame 14 is pivoted in journal 15, adjustment of such frame being accomplished by hydraulic jack 16 the plunger of which terminates for purposes of adjustment in screw nut 17 (for which lock nut 17a is provided), the end of the screw nut 17 contacting with a laterally extending portion 17b of said frame 14. The position of the frame and hence the doctor bar 28 is locked by means of screw bolt 18 in machine frame 19 which contacts with arm 19a of frame 14, and by screw bolt 20 in laterally extending portion 21 of frame 19. Similar adjusting devices, not shown, are provided at the opposite end of roll 10.

Frame 14 includes an I-beam 25, Fig. 3, to which is welded for additional strength a channel 26, Fig. 3. Supported by the I-beam-channel assembly is a casting 27 constituting a bearing for the doctor bar 28, said casting 27 being attached to the I-beam assembly by means of bolts 29. It will be noted that casting 27 is provided with a V-shaped slot 30 the side walls of which have embedded in them special bearing blocks 31, 32 of micarta, babbitt, bronze or other suitable bearing material. If desired, these insets may be omitted, especially when casting 27 has been made of bronze or other suitable bearing metal. By virtue of the supporting structure thus far described, the doctor 28 is firmly supported along its entire length, whereby it is prevented from bending or otherwise yielding unduly to the pressure of the coating color. This is important, inasmuch as a slight deviation of the doctor roll will affect adversely the evenness of the coating applied. For example, a deviation of the doctor roll in excess of .0001 inch may result in an increase of more than two pounds per ream per side. (One ream equals 500 sheets 25 × 38 inches.) In the embodiment described, doctor bar 28 is of 1 and $\frac{3}{32}$ inches radius and 111 inches long, whereas the transfer roll is of 12 and $\frac{1}{16}$ inches radius, i. e., about ten times that of the doctor bar.

The casting 27 preferably includes an upstanding reinforced (ribs 34a) portion 34 which houses an agitating device comprising a shaft 36 having secured thereon a pair of co-linear reversely pitched helical vanes 37, 38, which have the effect of causing a flow and hence mixing of the color from the center portion of the trough (45a) formed by casting 27 and squeeze roll 10. Shaft 36 is supported for rotation in bearing member 39 attached to the beam assembly 25, 26, by bolt 39a and in bearing 40 carried by bracket 40a attached to casting 27. Shaft 36 is driven through flexible coupling 41 by conventional means, not shown. It will be understood that various other types of agitating devices may be employed if desired, and that in some instances the agitating device may be omitted. Color is introduced to the trough preferably at the center through feed pipe 45. Side plates form the ends of the color trough 45a constituted by the casting 27 and the roll 10, such plates being of special construction and consisting preferably of a wear-absorbing inner plate 47, as for example micarta, and an outer metal plate 48, such plate assemblies being attached to the respective ends of casting 27 by bolts, one of which, 49, is seen in Figs. 2 and 4. A bolt 50, Fig. 7, which screws into metal plate 48 adjusts the pressure of the micarta plate 47 against the end of roll 10. Said micarta plates 47 preferably have a groove 51, Fig. 3, to catch color carried around by roll 10 and return it to the trough 45a.

Doctor bar 28 is driven by a motor 52, variable speed gear boxes 53, 54 and flexible couplings 53a, 54a, as will be obvious from Fig. 5.

In view of what has thus far been stated concerning the roll 10, it will be seen that the function of the resilient covering therefor, 10b, is of great importance. Thus it must be sufficiently resilient to form an enlarged contact zone with the doctor bar 28, while firm enough to withstand the pressure of the doctor bar, which is considerable, being as a rule more than 77 pounds per linear inch. As has been stated, because of the deformation which it undergoes against the rigidly supported doctor bar 28, any irregularlity due to lack of levelness or roundness is compensated for. The importance of this will be realized when it is considered that the problem of the deflections of an end-supported roll extending the width of a large Fourdrinier machine is substantial, since the roll thus acts as an ordinary beam. Where, for example, the length of the roll 10 is more than 100 inches, the normal sag of such roll is several 10,000ths of an inch, which, if not compensated for, would create undue irregularity in the amount of coating applied to the paper, inasmuch as 1/10,000th of an inch in the variation is roughly the equivalent of about 2 pounds of coat per ream. Since as a rule not more than 10 pounds—and frequently less than 8 pounds—of coat is applied, such variation would normally be in excess of 20% and would be beyond the commercial tolerance allowed. In practice we have found a range of hardness of the covering 10a of from 80 P & J to 160 P&J to give satisfactory results with preference to the average figure of 120. Desirably the doctor bar 28, which, as already stated, is substantially smaller in diameter than the transfer roll 10, is chosen to have a relatively hard surface best obtained by chromium plating.

In use, the trough 45a is maintained filled with color to the approximate level shown, such color being fed thereto by means of pipe 45. The pressure of the doctor bar 28 against the surface 10a of revolving roll 10 causes a layer or film of color to be formed on said surface and to be carried thereby to the web 12 which is held against roll 10 by roll 11, which latter may have any suitable type of surface, e. g., of hard rubber of 0 P&J hardness, or of hard metal. The color is subjected to working between the rolls 28 and 10 aided by the enlarged contact zone formed therebetween, and also by the differential speed of the two rolls. Because of the shearing effect of the rolls 28 and 10 on the color, its initial viscosity is reduced several fold, enabling the film to be formed on the roll 10 and to be transferred to the paper. The revolving helical vanes 38, 38, if used, serve to maintain the homogeneity of the color bath in the trough 45a. The thickness of the coating applied is determined by the amount of pressure exerted by the doctor 28 against the yielding surface of the roll 10 and also by the composition of the color itself. For example, using the color composition given in Example I below, 8 pounds per ream of paper per side has been applied.

Referring to Fig. 1, which shows a preferred way in which our improved device may be installed as part of the paper making machine,

here the paper web 12, having been formed on the Fourdrinier and dried, is thereupon calendered on the calender 60 from which it passes to the improved coater A where it is coated in the manner above described on the under or wire side, thence passing to the nest of driers, the first of which, 61, is heated as by means of hot water to a temperature not substantially over 150° F. and preferably somewhat below this value, e. g., 130° F., the heat imparted by the roll being sufficient to hasten expansion of the sheet due to absorbed water whereby expansion is substantially complete before the fibers have set from the heat. The web now passes to the next roll of the 61 group, which is heated slightly higher, e. g., 160° F. Finally the paper passes over the third roll of the 61 group, where it is heated to a still higher temperature, e. g., 170° F. The paper now passes to the coater B of similar type but modified slightly as shown in Fig. 6, to be described, by which the top or felt side of the web is coated, the paper thereafter passing through the nest of driers 62, the first three of which are respectively maintained at substantially the same temperatures as the three driers in group 61, respectively. Inasmuch as the driers 62 do not take out quite all the moisture, still other driers are necessary, as shown in Fig. 1.

Referring to Fig. 6, color is applied to roll 10' by means of a rotating dauber roll 61' in color pan 63 and is thereafter doctored by pressure doctor 28' in a manner exactly similar as in the case of doctor 28, excess coating falling back into pan 63.

Examples of coating compositions used will now be given.

Example I

1,000 lbs. clay (filler type)
150 lbs. starch (oxidized)
20 lbs. casein
3 lbs. dispersing agent (sodium hexa meta phosphate)
Water to bring the mixture to 64.5% solids.

[Viscosity, #6 spindle, Brookfield viscosimeter.]

Speed	Factor	Reading	Centipoises
2	1,000	140	140,000
4	500	146	73,000
10	200	160	32,000
20	100	190	19,000

Thixotropic index—7.4, this value being taken as the ratio of the centipoise reading at the spindle speed of 2 to that at spindle speed of 20 (R. P. M.) of the Brookfield viscosimeter. The principle upon which this instrument operates is the measurement of the drag produced upon the cylinder or disc rotating at a definite constant speed (referred to as the spindle speed) while immersed in the material undergoing test. Reference to the next following graph will indicate that when logarithmically plotted the curves expressing variation of viscosity with spindle speed in R. P. M. are substantially straight lines. Thus the index so taken determines the curve. In general the thixotropic index should not be less than 5 for a color having an initial (i. e. at spindle speed of 2 R. P. M. in the Brookfield viscosimeter) viscosity of 5000+.

Example II

1,000 lbs. clay
170 lbs. starch (oxidized)
20 lbs. casein

3 lbs. dispersing agent (sodium hexa meta phosphate)
Water to bring the mixture to 58.3% solids.

[Viscosity, #6 spindle, Brookfield viscosimeter.]

Speed	Factor	Reading	Centipoises
2	1,000	76	76,000
4	500	78	39,000
10	200	80	16,000
20	100	92	9,200

Thixotropic index—8.3.

Example III

200 lbs. starch
½ lb. Na_2CO_3
60 gals. water
4 lbs. starch-dissolving enzyme.

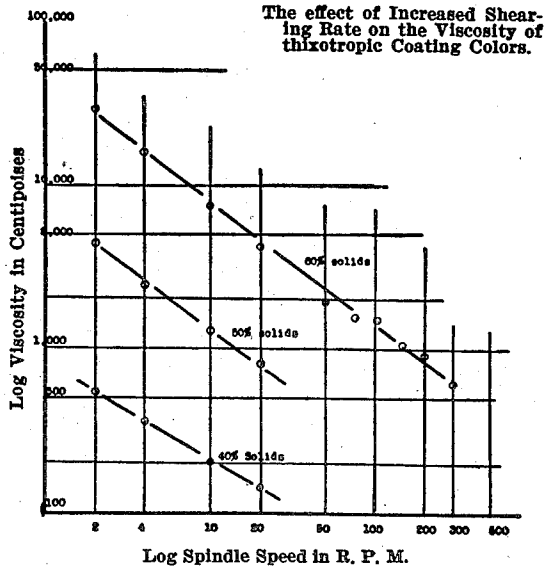
The starch was modified by heating to 170° F. and the enzyme inactivated by heating to 200° F. The starch solution was then added to the mixture and 1,000 lbs. clay mixed in along with 3 lbs. of sodium hexa meta phosphate as a disperser. The viscosity is shown in the following table:

[Solids, 62.3%; viscosity, #6 spindle; Brookfield viscosimeter.]

Speed	Factor	Reading	Centipoises
2	1,000	200	200,000
4	500	225	112,500
10	200	268	53,600
20	100	310	31,000

Thixotropic index—6.5.

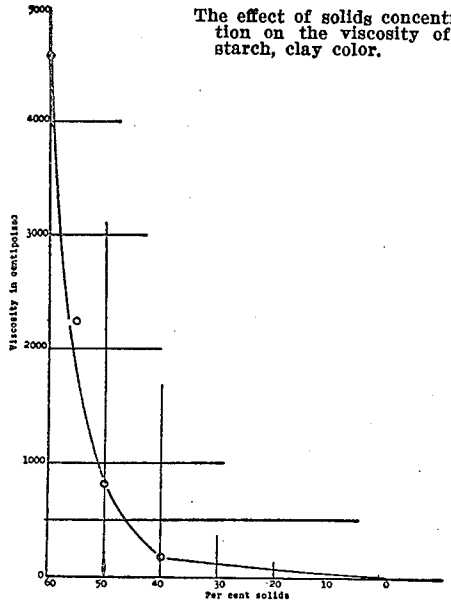
The effect of both of working the color in the Brookfield viscosimeter and of the solids content upon the viscosity is indicated in the following curve in which the abscissae represent logarithmically the spindle speeds, whereas the ordinates represent logarithmically the viscosity. It will be noted that, as logarithmically expressed, the curves are straight lines having slightly increasing slop values with increase in solids:



The color testing 40% solids was found not to apply well, giving a rippled surface, whereas the 60% solids color, while having a high viscosity to start with, is reduced by the action of the spindle to well under 1000 centipoises.

Furthermore, in order to obtain the best print-

ability the sheet should have as much coating applied to it as possible. This, in turn, requires that the color be of high solids content, but since viscosity increases markedly with solids content it is thus necessary to reduce the viscosity as by shearing action of the two rolls mentioned. The following curve shows the effect of increasing the amount of solids:



The effect of solids concentration on the viscosity of a starch, clay color.

We claim:

1. In a continuous method of making uniformly coated paper adapted for book and magazine use by applying to the paper a coating consisting essentially of mineral pigments and an adhesive in a suspension of water, and having an initial viscosity in excess of 2500 centipoises as determined by the Brookfield viscosimeter using a spindle speed of 2 R. P. M. and having a viscosity at a spindle speed of 20 of not more than one-fifth as much, the steps which comprise feeding said color between a pair of rolls one of which has a resilient surface, the other of which has a non-resilient surface, there performing work on said color by squeezing said rolls together under substantial pressure and producing an enlarged zone of contact in which said color is subjected to shearing action by moving the opposing surfaces at said zone of contact in the same direction at different speeds, such shearing action reducing the viscosity of said color and causing it to form a film on the roll having the resilient surface, and then immediately transferring said film from said roll to a continuous web of paper while said film is still flowable.

2. In a continuous method for making uniformly coated paper of the book or magazine type by applying an aqueous coating color containing mineral pigments and having an initial viscosity of at least 5000 centipoises as determined by the Brookfield viscosimeter using a spindle speed of 2, and a thixotropic index such that at a spindle speed of 20 the viscosity is not more than one-

fifth as of that at spindle speed of 2, to a continuous travelling web of base paper stock, the steps comprising rotating a resilient, yielding, deformable cylindrical surface against a substantially rigid, smooth rotatable metallic opposing cylindrical surface, applying pressure substantially uniformly along the full length of the metallic surface to deform said resilient surface and to create an enlarged contact zone between said surfaces, feeding said high viscosity color between said cylindrical surfaces, and subjecting same to shear by contact in said zone with said opposing surfaces moving at different speeds in the same direction at said zone of contact and urged together under pressure to reduce said viscosity of said color sufficiently to cause the same to separate in a film on said roll having a deformable surface, and immediately delivering said film of substantially uniform thickness from said roll to said base stock by passing the film in contact with said stock at substantially the same surface speed as the stock.

3. In a continuous method of making uniformly coated paper adapted for book and magazine use by applying to the paper a coating consisting essentially of mineral pigments and an adhesive in a suspension of water, and having an initial viscosity in excess of 2500 centipoises as determined by the Brookfield viscosimeter using a spindle speed of 2 R. P. M. which viscosity is too great to permit application of said color in a film without reduction of said viscosity, the steps which comprise feeding said color between a pair of rolls one of which has a resilient surface, the other of which has a non-resilient surface, there performing work on said color by squeezing said rolls together under substantial pressure and producing an enlarged zone of contact in which said color is subjected to shearing action by moving the opposing surfaces at said zone of contact in the same direction at different speeds, such shearing action reducing the viscosity of said color and causing it to form a film on the roll having the resilient surface, and then immediately transferring said film from said roll to a continuous web of paper while said film is still flowable.

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