This invention relates to the coating of paper, and more particularly to novel methods for applying to paper, coatings which are discontinuous but which in use give the appearance of being uniform. That is, the invention makes possible the production of a paper which gives the appearance of being uniformly and attractively coated yet the coating film is discontinuous in that according to a uniform, predetermined pattern there are fine areas which are uncoated, separated by areas of very small dimensions which are coated and on which the coating is impacted into the paper so that the fine coated and uncoated areas jointly form a comparatively level printing surface which may have a somewhat mat like appearance if desired and if it is not supercalendered. The fine coated and uncoated areas respectively are of such small dimensions that they are not independently readily noticeable as viewed with the naked eye at the intended distance for vision and consequently the paper presents the appearance of being entirely uniform. Yet since a considerable percentage of the total area is not actually coated, this appearance of a uniform coating is achieved by use of a substantially smaller amount of coating mixture than would be required to provide a continuous film coating with good printing qualities. The invention also relates to the product of the above-described method.

In the past, many grades of paper, particularly lower grades which bear printing, have not been coated because of the high cost and excessive added weight of the coating. Many such lower grades of paper need to be coated in order to enhance the printability and appearance thereof.

Another reason why papers of lower grade generally have not been coated is that heretofore it has been necessary to have a paper of superior fibre strength to carry the added weight of the coating. Papers of lower grade if relatively thin do not normally have such strength and more expensive raw material must be used if this requirement is to be met.

Conventional coating methods and apparatus have been heretofore incapable of producing a sheet having a satisfactory lightweight coating, for example, of the order of one to three pounds of coating per ream (26" x 38"—500 sheets) per side, which coating will appreciably improve the printability and the appearance of the sheet.

In addition, methods and apparatus proposed in the past for producing a lightweight and inexpensive coating have been unable to attain a desired apparent uniformity of coating or a coating which is sufficiently resistant to failure due to bending, scoring or abrasion.

Moreover, there are certain adhesives and binders which possess very desirable characteristics with respect to their coating properties but which have been unsatisfactory as coating ingredients due to their tendency to adhere or stick to metal surfaces used in the coating apparatus. Apparatus and methods suggested in the past under many circumstances have not been adapted for the application of such binders and adhesives satisfactorily.

Also prior methods and apparatus for applying very thin coatings have not been adapted to produce a coating which is sufficiently light in weight to be practical as to cost, and sufficiently uniform to avoid defective and unsatisfactory appearances. Such past apparatus and methods have produced coatings, for example, wherein peaks or ridges have shown through the coating and in some cases extended considerably above the level of the coating. Past methods and apparatus of this character have produced coatings which have been considered relatively lightweight but which have accentuated the surface irregularities of the paper because, for example, the coating mix has been concentrated in the valleys and depression in the paper stock.

Apparatus of this type heretofore proposed for applying a lightweight film of fluid material to travelling webs have involved use of the so-called "ink train method" similar to that used in letter-press printing processes. This has not been satisfactory for very thin coatings because of streaking and lack of uniformity of coating thickness.

According to the present invention, a coated paper and method for producing same are provided for satisfactorily avoiding the above noted difficulties.

The form of the invention illustrated in the accompanying drawings, by way of example, comprises a coated paper, and methods for applying, by intaglio means to a travelling web of sheet material, a coating of the above-described character. The coating is applied in accordance with a uniform minute pattern formed upon an applicator or coating roll. Such pattern, for example, can comprise a minute grid design or a plurality of minute, uniformly spaced, separate depressions formed in the applicator roll surface. A backing roll is employed with the applicator roll, these two rolls being urged together at a desired pressure and the travelling web passing therebetween. A fountain roll, which is
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partially immersed in a bath of coating mix, is preferably in direct contact with the applicator roll.

A doctor blade is employed for scraping off of the applicator roll all of the coating mix except that which is contained in said depressions whereby said roll can deposit directly upon the travelling web a plurality of minute portions or mounds of coating mix thus forming areas of very fine dimension which are coated and which are separated by areas also of very fine dimension which are uncoated.

The travelling web is next subjected to drying which solidifies the discontinuous coating. Thereafter the travelling web is calendered by a unit which compacts and presses inwardly upon the web the solidified coating. Substantial pressure is thus applied to the high areas of the coating, and since the coating does not have the yielding quality of the paper fibres, displacement will occur and the hills or mounds of coating mix will be substantially embedded in the paper, whereby a surface will be produced having greatly enhanced printing qualities and appearance. By virtue of the superior printing characteristics of the applied coating mix, a paper of superior printing surface is obtained which is very light and which are low cost heretofore sustained. Moreover, because of the fact that the coating mix will become substantially embedded in the paper, and because of the discontinuous nature of the coating, the latter will be less subject to cracking or peeling during calendering, bending or scoring as compared to a coating applied as a continuous film.

I have found, as above mentioned, that applying the coating as a direct print from an intaglio applicator roll substantially eliminates the occurrence of the discontinuous coating which normally might occur if an offset roll were employed. This preserves the discontinuous nature of the coating. It is important to preserve this quality because it enables the applicator roll to apply a coating with a uniformity which ordinarily would be impossible. The applicator roll, at the high or unprinted areas thereof, is in direct contact with the surface of the travelling web, whereby the coating is laid upon the web in a manner which is not affected by the usual variations in thickness and surface contours of the web. The fact that the backing and applicator rolls are urged together at a desired pressure assists in the laying down of the hills or mounds in this manner because the paper in effect is pressed to a substantial uniform thickness in passing between these rolls. The paper thereupon may possibly assume its original variations in thickness and surface contours. Said pressure can range from light to heavy as will more fully appear hereinafter.

The novel methods embodied in the invention thus make it practical to coat papers which could not be so treated economically in the past. Moreover, the printability and appearance of paper especially of the lower grades, is substantially enhanced by coating in accordance with the present invention.

Various, further and more specific features and functional advantages of the invention will clearly appear from the following detailed description when the latter is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not intended as a definition of the limits of the invention, reference for the latter purpose being had to the appended claims.

In the drawings,

Fig. 1 is a side elevation illustrating somewhat schematically one form of apparatus for carrying out the present invention;

Fig. 2 is a detailed view of a portion of an applicator or coating roll used with the present invention, the surface formation being shown greatly enlarged;

Fig. 2a is a greatly enlarged view of a fragment of a paper web coated in accordance with the invention by the feed roll of Fig. 2;

Fig. 2b is a greatly enlarged view of a fragment of a paper web bearing a discontinuous coating of uniform pattern of the grid type, the coating being applied in accordance with the present invention;

Fig. 2c is a greatly enlarged view of a fragment of a paper web also coated in accordance with the present invention but bearing a coating of the checkerboard type;

Fig. 3 is a greatly enlarged fragmentary detailed view of a paper web passing between a coating roll and a backing roll wherein the web is subjected to relatively high pressure;

Fig. 4 is a uniformly coated fragmentary detailed view of a paper web passing between a coating roll and a backing roll wherein the web is subjected to relatively light pressure;

Fig. 5 is a greatly enlarged cross-sectional view of a paper web prior to final calendering having mounds of coating mix applied thereto;

Fig. 6 is a still further enlarged cross-sectional view of the web and coating shown in Fig. 5 after the same has been calendered.

In the form shown in the drawings, the apparatus for carrying out the novel method is constructed by an intaglio coating device 10 employed in combination with a drier 11 and a calender 12. These elements are employed, for example, in cooperation with and as parts of a paper making machine, including a Fourdriner unit 13, a pattern roll 14, a drier 15 and a breaker stack 16. Five drier rolls 15a are shown, but any desired number can be employed depending, for example, upon the desired dryness of the web prior to coating, the grade and weight of the paper, and the speed of the web.

The paper pulp or stock is fed to the Fourdriner unit from a head box 17, the pulp passing to a wire screen 18 which can be driven in a conventional manner by a couch roll 19 and supported by a breast roll 20. Suitable straps, as at 21, are provided to keep the stock within the edges of the wire 18. Suction boxes 22 are employed which act in a well known manner beneath the upper run of screen 18 and the paper fibres are laid down on said screen by a dandy roll 23 and a couch roll 24 also in a well known manner.

A web of paper 25 issues from between the couch rolls 19 and 24 and passes to the press rolls 14 above mentioned. Suitable felt support blankets (not shown) can be employed for guiding the web relative to the press rolls 14.

Thereafter the web 25 passes through the drier 15 and thence to the breaker stack 16 from which it issues in a dried or partially dried form to the coating unit 10.

The breaker stack 16 should not compress the web to any appreciable extent but performs only its conventional function.

It will be understood, of course, that power is
applied by suitable gears, shafts and other mechanism to the rolls described herein. The web 25 passes from said stack 16 over an idler roll 26 to the coating unit 10. The latter is constituted by a backing roll 27 and an applicator or coating roll 28, these rolls being urged against one another with the web 25 passing therebetween. Suitable means are provided for urging these rolls together, comprising, for example, springs 29, located one at each extremity of roll 27, which act against shiftable journals or bearings 30. The journals 30 are movable in a suitable slotted support member 31 whereby the roll 27 can be shifted toward or away from the applicator roll 28. A hand wheel and threaded shaft 32 at each extremity of the roll 27 provide means for adjusting the compression of springs 29.

A fountain roll 33 is partially immersed in a bath of coating mix 34 contained in a receptacle 35. The fountain roll 33, in the form shown, is in direct contact with the coating roll 28. A doctor blade 36 is employed for substantially entirely removing the coating mix from the roll 28 except for the small amount which remains in the minute depressions outside the reach of the blade.

Two examples of coating mixes which have been found to be satisfactory are:

1. Clay .......... lbs. 100
   Coating starch .......... lbs. 20
   Neutral white soap ...... lbs. 0.2
   Water ................ lbs. 99

2. Clay .......... lbs. 100
   Casein ............... lbs. 15
   Ammonia ............. lbs. 75 (26° Baumé)
   Water ............ lbs. 94.5

The weight of the coating applied per unit area, of course, is a function of the number and size of depressions in the applicator roll. The percentage of solids in the coating mix will also affect the weight of coating applied and I have found that good results are obtained when the coating mix contains solids at the highest practical percentage. This speeds the drying of the coating and reduces the tendency thereof to coalesce and to become distorted.

As indicated in Fig. 2, the coating is not applied upon the surface thereof with a plurality of uniformly spaced and uniformly arranged minute depressions 28a which, for example, can be knurled or engraved or etched therein.

I have found that the discontinuous coating of uniform pattern is better applied by the intaglio method, that is, as a direct print from an intaglio roll, because of the substantial avoidance of coalescence of the coating. This is important because a coalesced coating of this general character cannot be so uniformly applied, is subject to streaking, and furthermore, often permits unsightly defects to appear in the finished sheet caused, for example, by protruding fibres and cockles.

As shown in Fig. 2a, the coating is applied to the web 25 without coalescence, the pattern being composed of a plurality of uniformly spaced hills or mounds which, for example, are substantially circular when viewed from above. The hills or mounds, instead of being in this shape, can be substantially square and arranged in a grid pattern as shown in Fig. 2b, or arranged in a checkerboard pattern, as in Fig. 2c. Any substantially uniform arrangement of substantially uniform hills or mounds of this minute character can be employed. It is understood that the views of the discontinuous coatings in Figs. 2a, 2b and 2c are greatly enlarged and that normally the hills or mounds thereof are not readily discernible, as has been above described.

Further, with respect to the size of the coated areas or mounds of coating material, I have found that the maximum dimension (length or diameter) thereof should not exceed about .0080 inch. Regarding shape, any circumscribed figure can be used. As to spacing, the distance between two coated areas (having no intervening coated areas therebetween) should not exceed about .0080 nor be less than about .0020. Of course, it is possible to apply mounds of the maximum dimension separated by the minimum distance. The checkerboard pattern of Fig. 2c shows the corners of adjacent coated areas actually in contact with one another. This, of course, is within the purview of the desired range of spacing. The minimum spacing dimension of about .0020 has reference to the distance to the nearest coated areas other than those shown as in Fig. 2c. If the above-mentioned limits of dimensions are employed, each coated and adjacent uncoated area will be of such size that they will subtend a visual angle less than that required for conscious resolution by the unaided eye at a normal distance, for example fourteen inches, at which the surface is to be viewed.

The drier 41, in the embodiment shown, preferably includes means, as at 31, for directing a plurality of jets of hot air upon the coated web, and a plurality of drier rolls 38.

The drier unit accomplishes a complete setting or solidifying of the coating and prepares same for the calender 12. The latter consists, for example, of a stack of nine rolls 39 which apply heavy pressure to the coated paper. The web 25 is led to the top of the calender and issues therefrom between the bottom two calender rolls. Adjacent rolls of the calender are urged together by suitable pressure applying means without any very substantial wiping action whereby the hills or mounds of the uniformly patterned discontinuous coating are pressed inwardly, smoothed out without coalescence and substantially embedded in the paper (Fig. 6). The coated surface of the paper is thus made much smoother than it was prior to calendering but the discontinuous nature of the coating is preserved. Of course, greater pressure is applied to the high areas of the coating than to the valley areas of the web, and as the coating mix is of less yielding nature than the paper fibres, the above-mentioned substantial embedding action takes place.

After calendering, the web is reeled upon a suitable core as at 40.

The novel product of the above-described method is indicated in cross-section in Fig. 6. The product during an intermediate stage of its fabrication, is also indicated in cross-section in Fig. 5.

I have found, as above mentioned, that it is necessary to calender the web of Fig. 5 in order to improve the printing qualities of the coated paper and in order to enhance the appearance thereof. However, in addition to these reasons, it is important to calender the web in order to cause the mounds 41 to become more strongly adhered to the paper than heretofore possible in any discontinuous coating previously proposed.
After the discontinuous coating has been applied and has solidified, the calendering of the web thus coated embeds the mounds $41$ into shallow pockets or depressions $25b$ which because of the embedding action may be slightly raised above their normal level. The formation of the shallow impressions or pockets $25a$ causes the coating to be very strongly adhered to the paper and enables the fibrous fingers of the web to take hold of each mound in a novel and forceful manner. The novel holding action is especially marked around the lips of the depressions. This prevents the mounds from "dusting off" and provides a guard against abrasion and cracking to an extent which has never before been attained.

Regarding the pressure between the applicator roll $28$ and the backing roll $27$, the amount of positive pressure will depend upon: the wetness of the paper; its smoothness; and its thickness. If the paper is moist, smooth and thin, only enough pressure is needed to secure a firm contact. If the paper is rough and thick, a higher pressure is needed. For example, in the case of kraft the web surface is wavy and rough, and sufficient pressure should be applied to compress the web between said rolls to a substantially uniform thickness to insure even deposition of the mounds.

Certain types of paper when greatly enlarged can appear in cross-section to have an undulating but relatively smooth surface as shown in Figs. 3, 4, 5 and 6. The proper compression of the web between the applicator and backing roll enables the even deposition of the mounds, as shown in these figures, over this entire surface regardless of its undulating nature.

With respect to the hardness of the backing roll $27$, if the web is hard, thick and stiff, such as steel, it should be used as in Fig. 3. But if the paper is relatively soft and thin, such as groundwood newprint, a resilient backing roll can be employed, for example of rubber as shown in Fig. 4, having a durometer hardness of about 50.

The degree of embedding is a function of the type of fiber employed and of the thickness of the web. If the fibers are relatively hard and the web relatively thin, for example, bible stock having a thickness of about two thousandths of an inch before calendering, there will be embedding to a less degree than where, for example, an ordinary groundwood newprint stock is used having a thickness of about three thousandths before calendering.

The novel method permits the application of coatings, for example, of a conventional starch or casein variety, in amounts which are substantially less per unit area than heretofore possible. A coating which is approximately one-half to one-third of the weight of minimum coatings heretofore possible can be applied by means of the present invention, such lightweight coating being feasible as to cost and providing greatly enhanced appearance to the paper.

The uncoalesced and substantially leveled discontinuous coating constitutes only a light burden for the paper, thereby making it unnecessary to have fibers of high strength which heretofore have been required in relatively thin papers to support the added load of the coating. The intaglio application under pressure of the discontinuous coating permits of a highly uniformly patterned, unstrained, and generally unblemished coating which is substantially free from defects caused by slight variations in web thickness.

Greatly enhanced printing qualities are achieved by virtue of the coating and the substantial leveling thereof.

In the above-described embodiments of the invention, the application of the coating is made in the middle of the dryer bank of the paper machine. However, the coating can be applied at an earlier point in the drying of the web but not until about eighty per cent of the moisture has been removed from the web. Of course, the coating can also be applied after the web is fully dry. Also coatings can be applied to both sides of the web, for example, by employing two coating units $16$, as described above, one for each side of the web.

Coatings can be applied by this method to paper stock as a separate operation after the stock has been made in the usual manner, provided the paper has not been highly calendered or provided it has sufficient thickness and yielding quality to allow adequate impacting or embedding of the mounds comprising the coating.

While the invention has been described with respect to certain preferred embodiments, if the invention is given satisfactory results, it will be understood that various changes may be made without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention, reference will be had to the appended claims.

What is claimed is:

1. The method for coating paper with a discontinuous coating of a substantially uniform pattern which consists in: subjecting a traveling web of paper to pressure between a backing and a coating roll, the latter having a plurality of minute depressions formed in the surface thereof in a uniform pattern, said coating roll having a coating mix continuously applied thereto, the coating mix being removed from the undepressed areas of the coating roll but being retained in the minute depressions until deposited on the web in separate minute mounds; thereafter dehydrating the separate minute mounds so applied to the paper to solidify same thereby to maintain the individuality of said mounds whereby coalescence thereof is prevented; and then subjecting the web of paper to a pressure between calender rolls for substantially leveling the upper surfaces of the mounds.

2. A coated fibrous sheet product comprising a sheet of paper-like substance having a mineral coating material disposed on at least one side thereof, such sheet normally being of varying thickness and thus having an undulating surface with some areas thereof positioned higher than others relative to a central plane of the sheet, the coating being characterized by a plurality of minute fine areas which are coated by mineral coating material in the shape of fine mounds, such coated areas and mounds being separated by minute areas which are uncoated, the coating being in a discontinuous form according to a uniform predetermined pattern, the fine mounds being impacted into the paper, the coating material being of a strength which heretofore would have caused the fibrous sheet being impacted therein to a greater extent than the coating material on the relatively lower areas of the sheet, the upper areas of the coating material being thus pressed to a substantially common level.

3. The method for producing a mineral surfaced paper web for receiving printed impres-
sions which consists in: forming a continuous paper web by means of a paper making machine, partially dehydrating said web by the application of heat until it contains not more than about 20-30% moisture, said web having a pre-selected yielding characteristic throughout its area while so partially dehydrated, thereafter applying to the web a coating mixture by direct intaglio printing and according to a fine, uniform, discontinuous pattern by passing said web between a coating roll of rigid material having formed therein a plurality of minute depressions embodying said pattern and a resilient backing roll whereby the undulating surface of the web which passes in contact with said rigid roll is urged thereagainst throughout its area, the coating mixture in such minute depressions of the coating roll being evenly deposited upon both the high and low areas of such undulating web surface, then heating the travelling web to solidity such coating mixture thereon immediately after the application thereof whereby discontinuity of the fine, uniform, discontinuous pattern is maintained and coalescence of the elements of such pattern is prevented, and further said web is substantially fully dried, and finally subjecting the travelling web with the fine pattern coating thereon to substantial pressure whereby the coating material upon the relatively higher portions of the fibrous sheet are impacted therein to a greater extent than the coating material on the relatively lower areas of the sheet, the upper areas of the coating material throughout the area of the web being thus pressed to a substantially common level, each fine coated area and an adjacent uncoated area being of such fine dimension that they sub tend a visual angle less than that required for conscious separation by the eye at a normal distance for vision.

5. The method for producing a mineral surfaced paper web for receiving printed impressions which consists in: applying to the web a coating mixture by direct intaglio printing and according to a fine, uniform, discontinuous pattern by passing said web between a coating roll of rigid material having formed therein a plurality of minute depressions embodying said pattern and a backing roll whereby the undulating surface of the web which passes in contact with said rigid roll is urged thereagainst throughout its area, the coating mixture in such minute depressions of the coating roll being evenly deposited upon both the high and low areas of such undulating web surface, then heating the travelling web to solidity such coating mixture thereon immediately after the application thereof whereby discontinuity of the fine, uniform, discontinuous pattern is maintained and coalescence of the elements of such pattern is prevented, and further said web is substantially fully dried, and finally subjecting the travelling web with the fine pattern coating thereon to substantial pressure whereby the coating material upon the relatively higher portions of the fibrous sheet are impacted therein to a greater extent than the coating material on the relatively lower areas of the sheet, the upper areas of the coating material throughout the area of the web being thus pressed to a substantially common level, each fine coated area and an adjacent uncoated area being of such fine dimension that they sub tend a visual angle less than that required for conscious separation by the eye at a normal distance for vision.

Paul A. Snowman, Jr.

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