

Dec. 29, 1931.

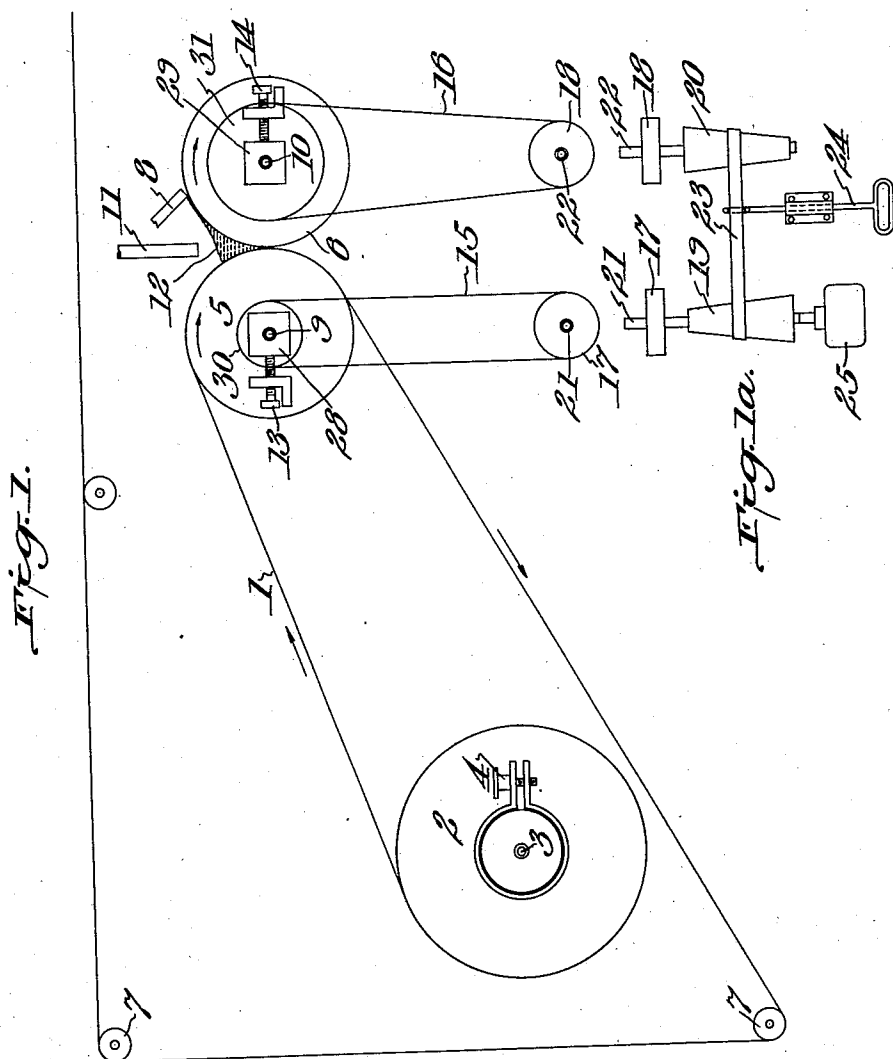
D. B. BRADNER

1,838,358

PROCESS FOR MAKING COATED PAPER

Filed Feb. 11, 1929

3 Sheets-Sheet 1



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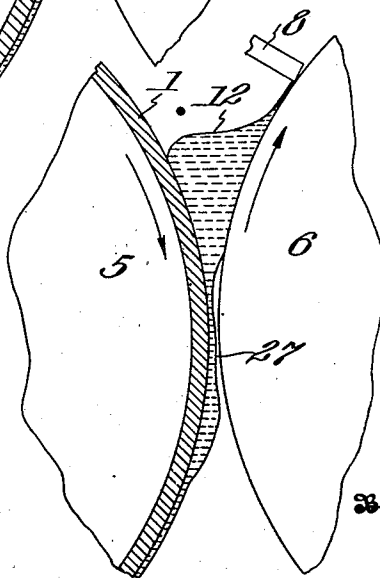
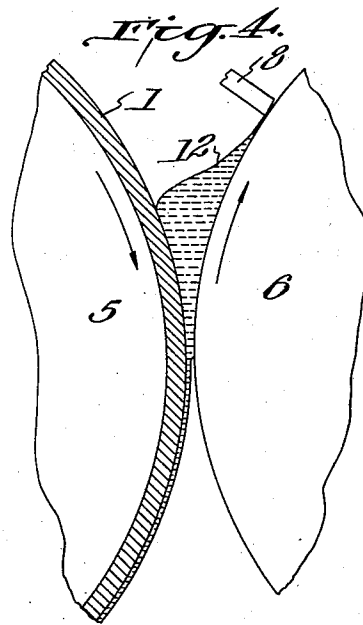
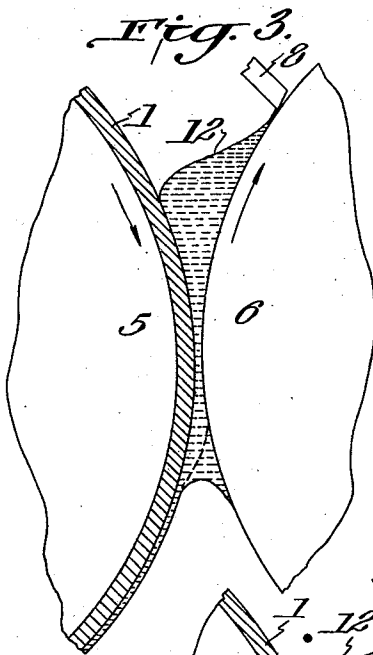
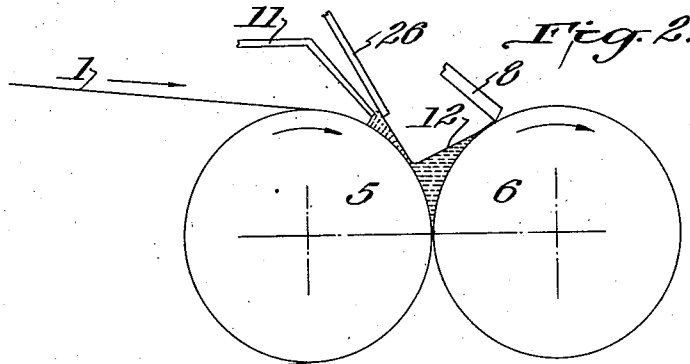


Fig. 5.

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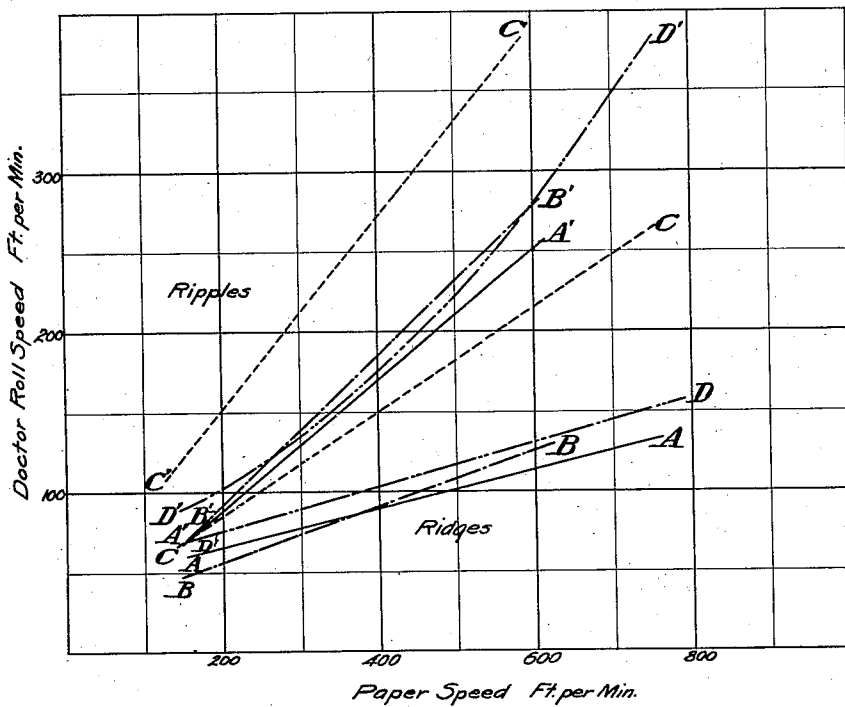
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Fig. 6.



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UNITED STATES PATENT OFFICE

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PROCESS FOR MAKING COATED PAPER

Application filed February 11, 1929. Serial No. 339,165.

This invention relates to an improved process for making mineral coated paper.

By the expression "mineral coated paper" is meant a paper (including cardboard) raw stock or base, which has been coated with an aqueous suspension of mineral pigment and adhesive. The mineral pigment may be, for example, clay, satin white, calcium carbonate and the like; the adhesive may be, for example, casein, starch and the like.

Paper may be coated on one side or on both sides. When only one side of the paper is to be coated, the common practice is to apply aqueous coating mixture to the travelling web of paper by means of a rotating brush, the brush picking up the coating mixture from a roll rotating partially submerged in a pan containing the coating mixture. When coating both sides of the sheet simultaneously, the usual procedure is to flow the coating mixture onto the sheet as the latter passes between two rotating squeeze rolls. The lower squeeze roll dips into a pan containing coating mixture supplied from the stream of coating mixture flowing over the edges of the paper in front of the top squeeze roll. Although I have described the usual practice of applying the coating to the paper in the coated paper industry, a number of other means have been proposed, but all the methods, as far as I am aware (except the one described in my copending application Serial No. 259,262, filed March 5, 1928), and its continuation-in-part, Serial No. 290,093, filed July 3, 1928, consist in first applying a desired weight of coating to the paper, and then, as a separate operation, spreading this coating into a more or less uniform layer before drying, this spreading being accomplished by means of brushes, rolls, or equivalent means. A secondary spreading operation such as that just mentioned is open to a number of objections, among which may be mentioned the tendency of the spreading means to mark the paper, especially when a fairly viscous coating mixture is employed. Thus coated paper is frequently marred by "brush marks" or by ridges from smoothing rolls.

In my copending application Serial No.

259,262, and in the continuation-in-part thereof, Serial No. 290,093, filed July 3, 1928, I have described a novel coating apparatus and method of coating, characterized by applying a coating mixture to a roll, smoothing the coating mixture on the roll, and then transferring the smoothed layer of coating onto the paper, the roll rotating in the opposite direction to the travel of the paper. The said method includes the optional step of conditioning or "pre-wetting" the paper web whereby to displace any air which otherwise might become entrapped in the paper by the film of coating thereafter formed thereon and thus cause "skips" in the finished coating. It is there described that this conditioning or "pre-wetting" may be effected by treating the paper web with a wetting agent which may be a portion of the aqueous coating composition, water alone, and adhesive solution, a solution of a dyestuff or steam, and thereafter forming the film of coating on the so-wetted web. Where a liquid wetting agent is employed, the wetting step may be effected by passing the uncoated web surface in contact with a surface, such as the surface of a roll, carrying a film of the wetting agent.

The present invention accomplishes the same results as the novel roll coater described in the above mentioned application, namely:

1. It applies to the paper a coating which is so smooth and uniform that it requires no subsequent spreading or brushing before drying.
2. It permits the application of coatings containing less water than is customarily required, thus reducing the amount of drying necessary and also improving the quality of the coated paper.
3. It permits the application of heavier or lighter coatings than is normally possible with the customary coating machine.

The present invention, in addition to accomplishing the above mentioned results, provides the following further advantages:

1. It provides a more positive method of coating the web.
2. It permits the use of coating mixtures of an even higher viscosity.

3. It gives improved results with cockly or wrinkled paper.

4. It decreases the tendency to rub up the fibers, which rubbing up produces a fuzzy and mottled sheet.

The invention will be more particularly described with reference to the accompanying drawings, of which:

Fig. 1 diagrammatically represents, in elevation, one form of apparatus adapted to perform the process of the invention;

Fig. 1a represents a detail of Fig. 1 in plan view;

Fig. 2 represents a modified form of apparatus adapted to perform the process of the invention;

Figs. 3, 4, and 5 are diagrammatic representations of the phenomena occurring in the coating of paper; and

Fig. 6 is a graphical representation of the critical conditions associated with the phenomena represented in Figs. 3, 4 and 5.

Referring to Fig. 1, 1 is a web of paper being unwound from the roll of paper 2. The roll of paper 2 is mounted on the shaft 3 and is equipped with a brake 4 of standard construction well known in the industry, whose purpose is to regulate the tension on the paper. 5 is a pull roll rotating in the direction indicated by the arrow. The paper passes partly around the pull roll 5 and through the nip or opening between the pull roll 5 and the doctor roll 6. The paper then passes back around the fly rolls 7-7 and finally out to a standard drying system not shown. Pull roll 5 is a metal roll and it should be smooth, round, straight and concentric with its journal 9. The doctor roll 6 rotates in the direction indicated by the arrow, which it will be noted is contrary to the direction of the travel of the paper at the narrowest point of the nip. It is made of metal and should be smooth, round, straight and concentric with its journal 10, and should not be absorbent to aqueous coating mixtures. The surface of the roll should be free from such grooves, scratches, and other blemishes as would show up on the coated paper. The doctor roll 6 is provided with a wiper 8. The wiper 8 may be of rubber, felt, soft metal, or other suitable material, the function of the wiper being to remove practically all the coating from the doctor roll so that the surface of the doctor roll is substantially free of coating mixture as it approaches the nip between rolls 5 and 6. More than one wiper in series may be used if desired. The coating mixture is supplied to the machine through the pipe 11, and under the proper conditions of operation it forms a pool or layer at 12 between the two rolls 5 and 6. The wiper 8 also helps to maintain the pool of coating 12. End plates (not shown) to form a dam to restrain the coating from flowing over the edges of the rolls, and also to

help maintain the aforesaid pool of coating, may be provided if desired.

The distance between the two rolls 5 and 6 can be varied by means of the adjusting screws 13 and 14 contacting with the bearings 28 and 29 of each roll. This adjusting equipment provides a means of regulating the weight of coating to be applied. Rolls 5 and 6 are driven through the belts 15 and 16, connecting pulleys 17 and 18 with pulleys 30 and 31, respectively. As indicated in the plan view, Fig. 1a, the pulleys 17 and 18 are attached to the cone pulleys 19 and 20, respectively, by means of the shafts 21 and 22, and the cone pulleys are connected together by the belt 23. The belt 23 may be shifted along the cone pulleys 19 and 20 by means of the belt shifter 24, thus providing for variably controlling the relative speeds of pull roll 5 and doctor roll 6. Pulley 19 is driven through shaft 21 by the source of power 25.

In order to obtain a satisfactory coating by means of this machine, it is necessary to operate it under certain predetermined conditions. I have carefully investigated the various factors affecting the operation of the machine, and by controlling these factors in the manner hereinafter described, I have succeeded in making mineral coated paper superior to mineral coated paper made on the customary brush coating machine, and free from many of the faults and difficulties inherent in existing coating methods.

In discussing the various factors involved, it will be advantageous to examine closely the phenomena which occur in applying a coating by this method.

It is well known that when an aqueous coating mixture is applied to paper by means of squeeze rolls rotating with the paper, the coating is not uniformly distributed on the paper but is concentrated in longitudinal ridges which require an elaborate brushing operation to spread them out into an even layer.

Mineral coated paper having this same ridged appearance is produced on my machine when the surface speed of the doctor roll is too slow relative to the paper speed. However, as the speed of the doctor roll is increased, these ridges gradually become smaller, and finally at a speed characteristic for each coating mixture, they entirely disappear and the coating on the sheet becomes smooth. If the speed of the doctor roll is still further increased, a speed is finally reached at which the coating on the sheet assumes a wavy or rippled appearance. These ripples may be heavy and broad, or small and numerous, depending on the speed of the doctor roll and the character of the coating mixture. As the doctor roll speed is still further increased, the ripples become smaller and closer together, eventually being no longer separate.

ly distinguishable, but the coating is more or less frothy, which produces large numbers of pin holes on drying. A coated sheet on which ripples or ridges exist requires a subsequent brushing or other smoothing operation, but a sheet coated at the correct doctor roll speed is very smooth and requires no additional smoothing before drying.

The formation of ridges, smooth paper and ripples, depending on the speed of the doctor roll, may be explained as follows: Under the conditions at which ridges are formed, that is, at very low doctor roll speeds, it is reasonable to believe that the pool or film of coating mixture takes the position indicated in Fig. 3. Gravity tends to cause the coating to flow downward through the nip and this tendency is of course greater as the hydrostatic head of coating mixture is increased. Increasing the hydrostatic head of coating mixture requires an increase in doctor roll speed for the formation of smooth coating, the amount of the increase depending on the particular coating mixture. The slower the speed of the doctor roll relative to the paper speed, the more pronounced is the ridged appearance on the paper, other things being equal.

On the other hand, if the speed of the doctor roll is too high with reference to the paper speed, a condition is believed to exist which is shown diagrammatically in Fig. 5. In this case, apparently a film of air is drawn up on the surface of the doctor roll underneath the coating. Periodically the coating breaks through this film and a relatively large quantity of coating passes through the nip and is deposited on the paper. Under these conditions the coating on the paper has a wavy or rippled appearance. At very high doctor speeds it may be assumed that the coating breaks through the air film with such frequency that the individual ripples are no longer separately distinguishable, but that the air drawn in and mixed with the coating causes froth.

Intermediate between the conditions favorable to the formation of ridged coating and a rippled coating, a certain balance is established between the forces tending to cause the coating to flow through the nip and the opposite force exerted by the doctor roll. Such a condition is indicated diagrammatically in Fig. 4, where the film of coating is seen to divide in the general neighborhood of the narrowest point of the nip. This represents the condition suitable for the production of a smooth uniform coating.

In other words, as the speed of the doctor roll relative to the paper speed is increased, the coating on the paper is first ridged, then smooth, then rippled, and finally smooth but frothy. Obviously these effects may be accomplished by maintaining the paper at a constant speed and increasing the doctor roll

speed, or by maintaining the doctor roll at a constant speed and decreasing the paper speed.

The transition from one condition of coating to another is usually a very gradual one. For example, starting with a heavily ridged coating and increasing the doctor roll speed, the ridges become progressively thinner and fainter, gradually fading out until they are no longer discernible to even an experienced observer. Notwithstanding this difficulty in determining the exact transition points, the results obtained on repeated experiments have been remarkably reproducible, indicating that control over the various factors involved can be readily obtained.

I have conducted many hundreds of tests with my new method of coating paper, using all the various kinds of coatings commonly employed in the manufacture of mineral coated paper and a wide variety of raw stocks, and I have discovered that the appearance of ridges at low doctor roll speeds, ripples at high doctor roll speeds, and a zone of smooth coating between these two ranges is a general phenomenon. It is not to be inferred, however, that these ranges are numerically the same for all kinds of mineral coating mixtures.

To illustrate in detail the conditions under which ridged, rippled and smooth coating is produced by my process, I will describe a series of coating experiments using machines of the types shown in Figs. 1 and 2. The pull roll and doctor roll were each steel rolls approximately 5 inches in diameter. Paper coating speeds ranging through the customary speeds used in coating mills and up to speeds much higher than ordinarily practiced were employed in these tests. The results with four representative coating mixtures (A, B, C, and D) will be given.

Coating A was a casein-clay-water mixture of rather high viscosity. Stormer viscosimeter gave 36 sec. Sp. Gr. 1.38. Total solids 48%.

Coating B was identical with coating A, except that it had a lower viscosity due to a larger percentage of water. Stormer viscosimeter gave 25 sec. Sp. Gr. 1.34. Total solids 44.5%.

Coating C was a starch-clay-water mixture containing also a small amount of satin white. Stormer viscosimeter gave 15 sec. Sp. Gr. 1.26. Total solids 40%.

Coating D was a casein-clay-satin white-water mixture with a viscosity (Stormer) of 15 sec. Sp. Gr. 1.16. Total solids 28%.

Coatings B, C and D, were coatings similar or identical with coatings commonly used with the usual type of brush coaters in coating mills. Coating A had a viscosity too high for successful operation with the usual brush coaters. Coatings B, C, and D, moreover are

typical of moderate grade, low grade, and high grade coatings, respectively.

The ranges of ridged coating, smooth coating, and rippled coating with these four coatings are indicated in Fig. 6. In this figure, doctor roll speeds are plotted against paper speeds. Considering, for example, coating A, ridged coatings are produced at all values below the line AA, rippled coatings are produced at values above the line A'A', and smooth coatings are produced in the zone between lines AA and A'A'. The upper limit of rippled coatings has not been plotted as it was not determined in many of the tests. Just to indicate the magnitude of this limit, it may be stated that for coating A at a paper speed of 120 ft. per minute, ripples disappeared between doctor roll speeds of 900 and 1400 ft. per minute. For coating C the limit was somewhat lower; at a paper speed of 200 ft. per minute, ripples had just disappeared at a doctor speed of 500 ft. per minute.

It will be noted that there is considerable variation in the zones of smooth coating for the various coating mixtures. There is apparently a greater variation between the smooth coating zone for the starch coating and the casein coatings than exists among the various casein coatings. In fact, the zone of ridges is not very different for all three casein coatings. In all cases the zone of smooth coating is wider at higher paper speeds, and it becomes narrower at low paper speeds.

In addition to the four coatings discussed above, a large number of tests have been made with other coatings consisting of aqueous suspensions of mineral pigment and adhesive. In all cases the zone of smooth coating is more or less wedge shaped, widening out at higher doctor roll speeds. The viscosity of the coating does not seem to exert any marked effect until a very watery condition of the coating is reached. At these very low viscosities, higher speeds of doctor roll are required for a corresponding paper speed before smooth coatings are obtained. Likewise, a much higher doctor roll speed is generally required for the formation of a rippled coating with very low viscosity coatings. It should be pointed out, however, that these extremely low viscosity coatings in general do not produce a coating of as good a quality as the more viscous coatings. The coating mixture has a tendency to flow out after leaving the coater and produce an undesirable appearance which for want of a better term I call "puddly".

Variation in the size of the rolls does not effect the result within experimental error. Doctor rolls and pull rolls of the same and different diameters have been tried out but without appreciable effects on the zone of production of smooth paper.

It is essential, however, that the opening between the rolls should not vary appreciably

during rotation of the rolls, as this permits alternately more and less coating to pass through the nip onto the paper with the result that the coating is deposited in thicker and thinner layers across the width of the sheet, giving the paper a ladder-marked appearance. Also, the opening must not vary appreciably across the length of the rolls, since this would cause a heavier weight of coating on one side of the paper than the other.

A wide range of weights of coating deposited on the paper has been covered, ranging from weights of 5 pounds up to 50 pounds on each side. (Weight of coating refers to the dry weight deposited on a ream of 500 sheets of paper 25 x 38 inches.) The weight of coating applied does not have a marked effect on the ridge-ripple range of coatings.

The weight of coating applied is most conveniently controlled by adjusting the opening between the two rolls. However, as the doctor roll speed increases there is a gradual decrease in the weight of smooth coating applied for any given opening between rolls. Also, the weight of coating increases somewhat at higher paper speed, other things being equal. Of course, the percent of solids in a coating affects the weight of coating very considerably. As indicating the magnitude of the values under discussion, it may be stated that with coating D applied to a paper .003 inches thick, a nip opening of .006 inches gave a coating weighing 14 lbs. at a paper speed of 200 ft. per minute and a doctor roll speed of 90 ft. per minute.

The method of coating herein described is not limited to any particular kind of raw stock. Excellent results have been obtained with the usual coating stock which is moderately hard sized, and also with unsized or waterleaf raw stock. Papers which are difficult to handle on the usual coaters may be more readily coated on my machine. Among such papers are cockled paper, paper having loose or tight edges (that is, the paper is longer or shorter at the edge than in the middle), etc.

In case a paper is used which is difficult to wet with aqueous coating mixture the device shown in Fig. 2 has proved useful. Fig. 2 shows diagrammatically an alternate arrangement for supplying coating mixture to the nip between pull roll 5 and doctor roll 6. The coating mixture 12 is delivered through the pipe 11 behind the guard plate 26. This plate almost touches the paper on the pull roll, so that the coating forms a seal between the edge of the guard plate and the paper.

It will be apparent that a number of modifications in the above described process and apparatus may be made without departing from the scope of my invention. Thus, while I have mentioned in describing the apparatus a pull roll and a doctor roll made of metal, other materials may be used for this purpose

such as, for example, rubber or bakelite. Likewise instead of a doctor roll, I may employ a belt which may be, for example, of metal, and which moves in a direction opposite to the travel of the paper at a predetermined uniform speed relative to the paper to produce a coated paper free from a ridged or rippled appearance. Also, instead of using stationary blades to clean the coating from the doctor member, the wiper means may be in the form of a rubber covered press roll rotating with the doctor member. Regardless of the particular form of the wiper, the cleaning action accomplished thereby mechanically removes the coating from the doctor member, leaving not more than a very thin film of coating on said doctor member.

In the preferred embodiment of the apparatus I have described the paper being carried by a pull roll. In some cases it may be advisable to carry the paper on a travelling belt or apron during its passage under the doctor roll. Another form of support for the paper as it approaches the doctor roll surface may be a stationary slightly arched surface over which the paper slides, the arched form tending to hold the paper out flat.

Furthermore, it is not essential that the coating mixture be applied to the paper immediately before the doctor member contacts with the resulting coating layer. Thus, coating mixture in excess of that finally desired on the sheet may be applied to the paper by any suitable means and the paper then conducted to the doctor member while the coating is still wet. The doctor member removes the excess coating mixture from the paper, which excess may be returned to the main coating mixture supply in any suitable manner.

It will be evident from the foregoing description that the present invention broadly comprises a method of making mineral coated paper wherein aqueous coating composition is applied to a moving web of paper in excess of the quantity desired on the finished paper, and the coating on the paper is contacted with a doctor member, the surface of which is continuously cleaned by mechanical means and moves in the opposite direction to the travel of the paper, at a predetermined distance from the paper and at a predetermined speed, to remove the excess of coating from the paper and to leave the coating remaining on the paper substantially free from a ridged or rippled appearance, and of the desired weight.

By the term "doctor member" I mean a roll or belt having a continuous surface non-absorbent to coating composition, as distinguished for example from a brush or a felt-covered roll.

I claim:

1. Process of making mineral coated paper which comprises applying a substantial

excess of aqueous coating mixture to a travelling web of paper, removing said excess except the desired weight of coating from said paper by means of a doctor member whose surface at its point of closest approach to said paper is spaced a predetermined distance therefrom and is moving in the opposite direction to the travel of the paper at a speed which will leave the coating remaining on the paper without apparent ridges or ripples, continuously cleaning the surface of said doctor member, and thereafter drying the coated paper.

2. Process of making mineral coated paper which comprises applying a substantial excess of aqueous coating mixture to a travelling web of paper, removing said excess except the desired weight of coating from said paper by means of a doctor member whose surface at its point of closest approach to said paper is spaced a predetermined distance therefrom and is moving in the opposite direction to the travel of the paper at a predetermined speed above that at which ridges are produced on the coated paper and below that at which ripples are produced on the coated paper, continuously cleaning the surface of said doctor member, and thereafter drying the coated paper.

3. Process of making mineral coated paper which comprises applying a substantial excess of aqueous coating mixture to a travelling web of paper, passing said paper through the constriction between a solid supporting surface and a doctor member, removing said excess except the desired weight of coating from the said paper by means of the doctor member whose surface at its point of closest approach to said paper is spaced a predetermined distance therefrom and is moving in the opposite direction to the travel of the paper and at a predetermined speed above that at which ridges are produced on the coated paper and below that at which ripples are produced on the coated paper, continuously cleaning the surface of said doctor member, and thereafter drying the coated paper.

4. Process of making mineral coated paper as defined in claim 1, characterized in that the web of paper is pre-wetted.

In testimony whereof, I affix my signature.
DONALD B. BRADNER.