

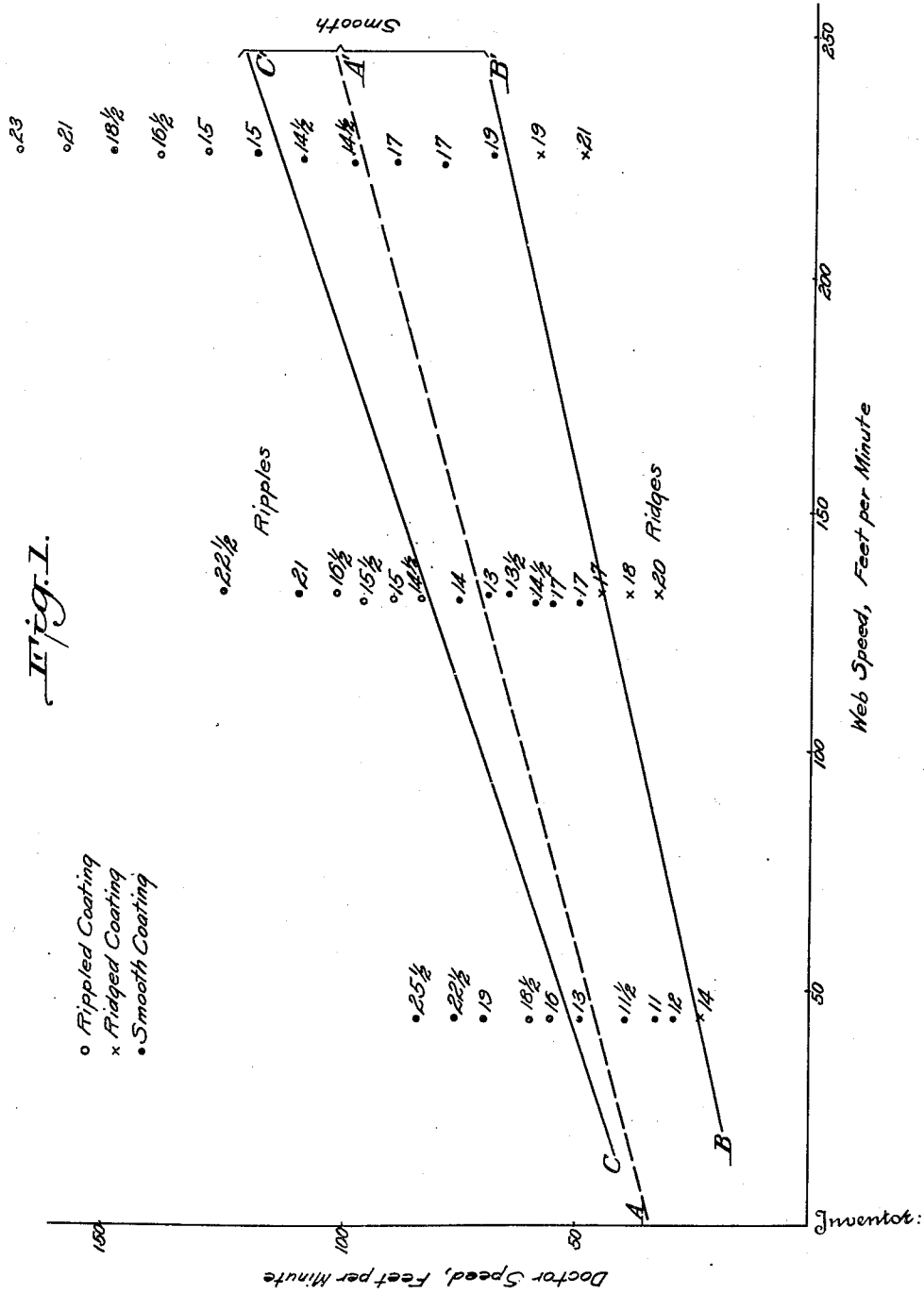
July 30, 1935.

W. J. MONTGOMERY
APPARATUS FOR COATING PAPER

2,009,631

Filed May 28, 1932

2 Sheets-Sheet 1



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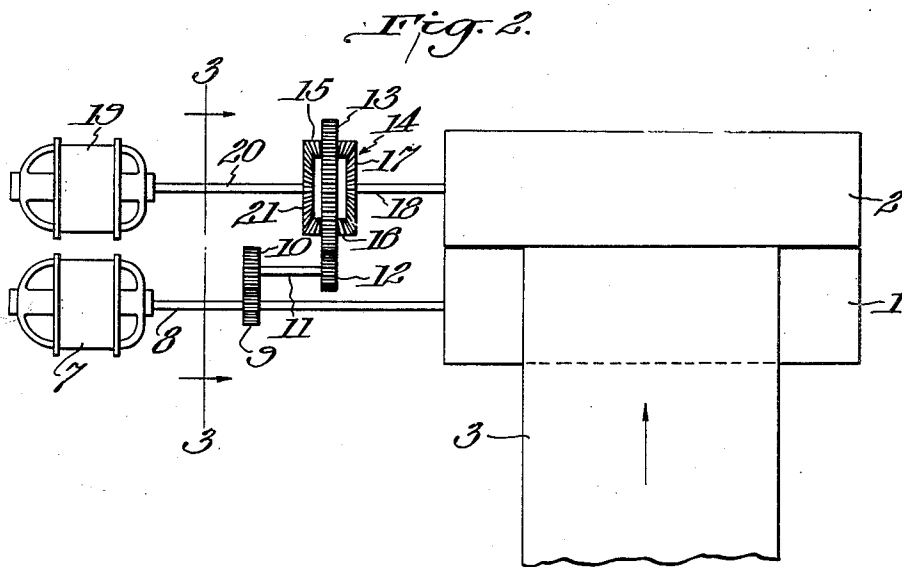
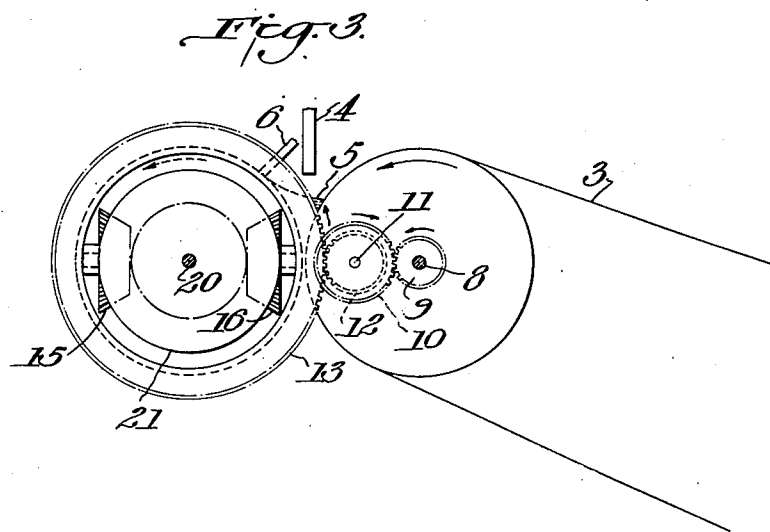
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UNITED STATES PATENT OFFICE

2,009,631

APPARATUS FOR COATING PAPER

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Application May 28, 1932, Serial No. 614,265

5 Claims. (Cl. 91-47)

This invention is concerned with the application of coatings in liquid form to web material such as paper and more particularly with the application of aqueous mineral coating composition to paper in web form for the production of what is commonly known as mineral coated paper.

This invention resides in apparatus for carrying out processes of making mineral coated paper of the type disclosed in U. S. Patent No. 1,838,358, granted Dec. 24, 1931, to Donald B. Bradner, and in a method of operation whereby smooth coatings of maximum uniformity of weight are obtained. In the process described in said patent an aqueous mineral coating composition is applied to a moving web of paper either by depositing an excess of the coating composition on the web and then removing all but the desired weight thereof, by a cleaned doctor member (hereinafter called the doctor), the surface of which at the point of closest approach to the web moves in the opposite direction, or by applying an excess of the coating composition to an intermediate applicator member (hereinafter called the applicator), such as a roll or belt, and thereafter removing the excess material from the applicator by a reversely turning cleaned doctor, and then transferring the residual layer of composition from the applicator to the web. The broad principle involved in these two procedures is the same, i. e. the formation of a smooth layer of coating, whether it be formed directly on the web or on an applicator from which it is transferred to the web, by first depositing on a carrying surface an excess of the coating in what may or may not be a smooth layer, and then removing the excess in such manner that a smooth layer of the desired weight is left on the surface. The latter operation requires, as is disclosed in the patent to Bradner referred to, a careful control of the relative speeds of the carrying surface and the doctor surface. As will be apparent, the principles involved may be embodied in a variety of specific apparatuses, e. g. the paper may pass between two rolls as described in said patent, and it may travel at the same speed as the roll on which it is carried or at a different speed, i. e. it may slip on said roll, or the carrier roll may be replaced by a mandrel over which the paper slides with its surface to be coated in cooperative relation to the surface of the doctor. In all such instances in which the excess of coating is deposited directly on the web and then smoothed by the action of the doctor, the speed of the web or of the mechanism which moves the web with

respect to the speed of the cooperating surface of the doctor, is the speed to be controlled. When the excess of coating is deposited on an applicator and smoothed thereon by the action of the doctor, and then transferred to the web, the relative speeds of the cooperating surfaces of the applicator and doctor is the speed to be controlled.

As is more fully explained in the aforementioned patent, for every particular composition of coating material there is a range of relative speeds of doctor surface and the surface carrying the excess of coating, i. e. the web or the applicator, which produces a smooth coating. It is there shown that where the speed of the doctor relative to the coating carrying surface is too high, the coating presents a rippled appearance, and where the relative doctor speed is too low, longitudinal ridges are formed in the coating.

I have observed that within the zone of relative speeds which produce smooth coatings, the weight of smooth coating applied varies with variations in the relative speeds of doctor and the coating carrying surface, and I have found that a substantially constant weight of coating may be applied as a smooth layer in spite of variation in the speed of the coating carrying surface, provided the relative doctor surface speed is maintained in accordance with an equation formula which is discussed more fully below.

In practical mill operation it is necessary to change the speed of the web and consequently the speed of the coating carrying surface from time to time due to changes in the drying rate, variations in the moisture content of the coating composition, variations in the paper being coated, etc. It is therefore necessary also to vary the speed of the doctor relative to the coating carrying surface in order to obtain the best results.

This invention provides a mechanism which automatically produces the speed relation expressed by the equation formula necessary to obtain the desired smooth coating of optimum uniformity of weight. The invention also provides a method of coating whereby smooth coatings of substantially uniform weight are produced in spite of variations in the speed of the paper being coated.

The invention will be described and illustrated hereinafter by reference to the type of apparatus in which the coating composition is applied in excess directly to the paper web and smoothed thereon, the web passing between a carrier roll and the doctor and it being assumed that the sur-

face speed of the carrier roll is the same as the speed of the paper, i. e. that the paper does not slip on the roll.

Referring to the accompanying drawings:

Fig. 1 is a graph showing the results obtained experimentally with a representative coating mixture at different relative speeds of the web and the doctor surface.

Fig. 2 is a more or less diagrammatic top plan view showing one form of apparatus employed in carrying out the invention, and

Fig. 3 is a section taken along line 3—3 of Fig. 2.

Fig. 1 is a graph of the results obtained when a representative casein-clay-water coating was applied to a web, the web and doctor surfaces being operated at a plurality of varying speeds. The values of web speeds in feet per minute are plotted as abscissae and the doctor surface speeds in feet per minute are plotted as ordinates.

On the graph are plotted three series of points representing a plurality of different doctor surface speeds at three different selected web speeds. The weight of coating of a selected coating composition and employing otherwise uniform conditions, particularly a fixed opening between the web carrying roll and the doctor, for the different speed ratios indicated by these points, are shown by the associated numbers. The condition of the coating produced is indicated as rippled, smooth, or ridged by the circles, dots and crosses, respectively.

The line B B' is drawn through the values representing the lower limit of the smooth coating and the line C C' is drawn through the values at the upper limit of the smooth coating range. Thus for any web speed there is a range of doctor speeds, bounded by the lines B B' and C C' within which a smooth coating will be produced. It will be noted that the coating of minimum weight which corresponds to any given web speed lies within the range of values which give a smooth coating.

The line A A' is drawn through the values representing the most uniform weights of coating within the zone of smooth coating. It will be noted that this line is a straight line whose equation is $D=bA+c$ where D and A are doctor and web speeds, respectively, and b and c are constants. I have found experimentally that this is a general expression of the phenomena relating to web coating by the process described and claimed in the aforementioned patent and that this equation, with the proper constants for each coating material, expresses the speed relation between doctor surface and the surface on which the excess coating is deposited and smoothed, which will produce a smooth coating of maximum uniformity throughout the range of web or applicator surface speeds. In the graph shown in Fig. 1, the equation for the line A A' is $D=0.28A+34$.

The apparatus for operating the coating elements and for automatically controlling the speed relationships between the web or the surface of the carrier roll, assuming that it moves at the same rate, and the doctor is shown in Figs. 2 and 3. Carrier roll 1 is arranged parallel to but spaced a predetermined adjustable distance from a doctor roll 2, and the web 3 to be coated passes over the roll 1 and through the space between the roll 1 and doctor 2. The roll 1 and doctor 2 are rotated in the same angular direction as indicated by the arrows. An aqueous mineral coating composition is supplied through a pipe 4 and forms a pool 5, as shown, a wiper member 6 coop-

erating with the doctor 2 and serving to clean the doctor 2 and maintain the pool 5.

A variable speed motor 7 is connected to the roll 1 by a main shaft 8 whereby the roll 1 is driven at the speed of the motor 7, although suitable reduction gearing (not shown) may be provided. The shaft 8 carries a pinion 9 which meshes with a gear 10 carried on a jack shaft 11 on which is mounted a second gear 12. The gears 10 and 12, together with the jack shaft 11, are removable for the purpose of inserting a set of gears having a different gear ratio. In place of this arrangement a change speed gearing mechanism (not shown) may be employed. The gear 12 meshes with the ring gear 13 of a differential mechanism 14 which carries a pair of travelling gears 15, 16. One bevel gear 17 of the differential mechanism 14 is connected by a shaft 18 to the doctor 2.

An auxiliary, normally constant speed motor 19 is connected by an auxiliary shaft 20 to the second bevel gear 21 of the differential mechanism 14 whereby the doctor roll 2 can be rotated at the speed of the motor 19, or if desired, reduction gearing (not shown) may be interposed.

It will now be seen that, if the auxiliary motor 19 is held stationary, and the main motor 7 imparts a speed A to the shaft 8, the roll 1 will be driven at a speed A, and the doctor 2 will be driven through the gears 9, 10, the jack shaft 11, the gear 12, the differential mechanism 14, and the doctor shaft 18, at a speed bA, where b is the ratio of the entire gearing interposed between the main shaft 8 and the doctor shaft 18.

Now if the auxiliary motor 19 is rotated in a direction opposite to the direction of rotation of the main motor 7, the bevel gear 21 will be actuated to add to the bevel gear 17 a speed increment proportional to the speed of the auxiliary motor 19. This increment of speed will impart to the doctor shaft 18 a speed increment corresponding to the speed of the auxiliary motor 19.

Hence the equation representing the relative speeds of the doctor 2 and roll 1 may be written $D=bA+c$ where A is the speed of the roll 1, b is the ratio of the gearing between the roll 1 and the doctor 2 (or in other words bA represents the speed imparted to the doctor 2 by the main motor 7), and c is the speed imparted to the doctor 2 by the auxiliary motor 19 acting through the differential mechanism 14.

The manipulation of the apparatus is as follows (assuming that it is desired to operate the apparatus according to the speed relation shown by the line A A' of the graph):

A set of gears 10, 12 and jack shaft 11, having a proper gear ratio, are inserted between the pinion 9 and the ring gear 13 whereby the peripheral speed imparted to the doctor 2 by the main motor 7 alone is 0.28 times the speed imparted to the roll 1. The main motor 7 is locked against movement, and the auxiliary motor 19 is rotated at such a speed as to drive the doctor 2 at a peripheral speed of thirty-four feet per minute. The main motor 7 is then started and brought up to the desired speed, which speed is, as before stated, determined by variant operating conditions. As the speed of the roll 1 is varied, by the control of the speed of the main motor 7, the speed of the doctor 2 is automatically varied in accordance with the equation $D=0.28A+34$, and hence the relation follows the line A A' representing optimum conditions of smoothness and uniformity of coating.

When it is desired to employ the apparatus with

a coating composition having different characteristics, the gear train 10, 11, 12, is replaced by a gear train having such a ratio that the factor "b" in the equation has the proper value and the auxiliary motor 19 is operated at the proper speed to add the proper value of "c" to the speed imparted to the doctor 2 by the motor 7.

I have illustrated and described one type of apparatus for carrying out the invention, but it will be apparent that the invention is not confined thereto. It is possible to employ any type of apparatus for carrying out the invention which comprises variable speed driving means for the surface on which the excess of coating is deposited, transmission mechanism for imparting to the doctor, speeds directly proportional to the coating carrying surface speed, and auxiliary driving means acting upon the transmission mechanism for adding a selected constant speed increment to the speed of the doctor. Such other types of apparatus may employ, instead of mechanical transmission means, hydraulic, electric, or other controllable means.

It will be understood that the phenomena above described relate as well to the method of web coating wherein the coating material is applied to an applicator, brought to the proper condition of thickness and smoothness, and thereafter transferred to the web and to apparatus wherein forms of coating elements other than rolls, such as, for example, endless belts, are employed.

It is to be understood that in the appended claims the expressions "transmission mechanism" and "speed differential" mechanism are not limited to any specific type of power transmitting means. It is further to be understood that the word "adding" is used algebraically.

I claim:

1. Apparatus for coating paper in web form with mineral coating composition comprising a

coating carrying surface, means for depositing coating composition in excess on said surface, variable speed driving mechanism for moving said surface in a predetermined path, a doctor member whose surface is adapted to move in cooperative relation to said coating carrying surface and in the opposite direction to remove the excess of coating composition therefrom, speed differential mechanism connecting said driving mechanism with said doctor member, and driving means connected to said differential mechanism for adding to the speed of the doctor member imparted thereto by said variable speed driving mechanism through said differential mechanism a predetermined constant speed increment.

2. Apparatus for coating paper in web form as defined in claim 1 in which the coating carrying surface is the paper web.

3. Apparatus for coating paper in web form as defined in claim 1 in which the coating carrying surface is the paper web, and the variable speed driving mechanism for moving the coating carrying surface in a predetermined path includes a carrier roll for the web and variable speed driving means connected to the roll.

4. Apparatus for coating paper in web form as defined in claim 1 in which the coating carrying surface is a roll, and the apparatus includes means for contacting a web of paper therewith to transfer coating therefrom to the web.

5. In a web coating machine the combination with an applicator roll and a doctor roll rotatable in the same angular direction, of a variable speed motor connected to drive the applicator roll, a differential gear interposed between said motor and said doctor roll, a second motor capable of delivering relatively constant speed, connected to and driving said differential gear to impart to said doctor roll a constant speed increment.

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