METHOD OF MULTIPLE COATING

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The present invention relates to a method of applying a plurality of separate coating materials to a support in layer relationship, and particularly to a method of applying all of the coating materials simultaneously while maintaining a distinct relationship between the different layers after they have been cured or dried on said support.

There are many instances in the coating art where it is necessary to apply two or more layers of coating materials, one on top of the other, so that the final product consists of a support having a plurality of distinct layers of the coating materials on one surface thereof. Depending upon the article involved, the different layers of coating will have different individual functions in the final product and it is, therefore, necessary that the individual coatings remain distinct from one another, i.e., that one layer not contaminate or mix with the adjacent layer and that each layer have a given thickness which may or may not be the same as the thickness of any of the other layers.

A classic example of such a multiply coated support is found in the manufacture of photographic films and papers. A simple photographic film may consist of a support of some cellulose derivative, i.e., cellulose acetate, which has coated on one surface thereof a light-sensitive emulsion and on top of that a coating of some transparent material whose function it is to protect the emulsion from abrasion. Such a film may also have a thin subcoat of some material applied to it before emulsion coating in order to facilitate spreading of the emulsion thereon and to increase its tenacity with the support. When one considers the colors sensitive photographic films, then there are several individual coatings which must be applied. There may be the subcoating, a blue sensitive emulsion, a red-sensitive emulsion, a green-sensitive emulsion, a protective coating, one or more color filtering coatings, etc.

The customary manner of applying multiple layers of coating materials to supports has been to apply each layer separately, one after the other, and to dry or cure each layer before the subsequent one is applied. Such a procedure has been slow and expensive since it involves much time and the duplication of coating and drying equipment. In an effort to cut down on the expense of such multiple coating, I am aware that one coating has been laid down upon a second coating after it has been applied but it is still fluid, the advantage of such method being that it cuts down on the drying equipment needed by allowing the two coatings to be dried at the same time. I am also aware that in order to obtain a final thickness of a certain coating on a support, it has been suggested that a plurality of thin coatings be successively applied to the support to build up to the desired final thickness, such technique being used to overcome certain problems encountered in drying a single coating of the desired thickness and maintaining the necessary uniform thickness and a flat surface. This last-mentioned coating technique is not analogous to the present invention since each layer is identical and contamination or mixing between layers is not a factor. Or, stating it another way, there is no necessity for keeping the individual layers distinct from one another.

One object of the present invention is to provide a method of applying a plurality of separate coating materials to a support simultaneously and still maintain a distinct relationship between the different layers.

Another object is to provide a method of coating a support with a plurality of coating materials simultaneously and curing or drying all of said layers at the same time while still maintaining a distinct layer relationship between the coatings.

A further object is to provide a method of coating as described wherein the thickness of the individual layers is controlled by the rate at which the different coating materials are fed into the coating bead.

And another object of the present invention is to provide a method of coating a plurality of colloidal materials onto a support in distinct layer relationship which comprises simultaneously applying each of the colloidal materials in solution form onto the support at the same point.

And still another object is to provide a method of coating a support in the manufacture of photographic film and/or paper which comprises simultaneously applying one or more light-sensitive emulsions, and/or sub-coatings, protecting layers and light filtering layers to the support at the same time and maintaining a distinct layer relationship as well as a desired thickness regulation of each layer.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its mode of operation, together with additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic, part side elevational, part sectional, view of a form of apparatus including a dual hopper which may be used to simultaneously apply two layers of coating material to a web in accordance with the present invention;

Fig. 2 is an enlarged sectional view of just the dual hopper used in connection with the apparatus of Fig. 1;

Fig. 3 is a greatly enlarged fragmentary section of the dual hopper shown in Fig. 2 and illustrating how two layers of coating material are simultaneously applied to the surface of a web;

Fig. 4 is a fragmentary section showing a color photographic film coated with four different layers of material and using a dual hopper;

Fig. 5 is an enlarged fragmentary section of a triple hopper by the use of which three layers of coating material may be applied to a surface of a web in accordance with the present invention;

Fig. 6 is a front elevational view of a multiple hopper which can be used to simultaneously apply four coatings to the surface of a web in accordance with the present invention;

Fig. 7 is a partial top plan view of the multiple hopper shown in Fig. 6;

Fig. 8 is a sectional view taken substantially on line 8—8 of Fig. 6;

Fig. 8A is an enlarged detail of Fig. 8 showing how the four layers of separate coating compositions are fed into the coating bead by the hopper;
Fig. 9 is a sectional view of a dual slide hopper by means of which two layers of coating material may be simultaneously applied to the surface of a web in accordance with the present invention. Fig. 10 is a sectional view of a multiple slide hopper by means of which four layers of coating material may be applied to the surface of a web simultaneously in accordance with the present invention. Fig. 11 is a sectional view showing a combined extrusion and slide hopper by means of which two layers of coating material may be simultaneously applied to a surface of a web in accordance with the present invention; and Fig. 12 is a sectional view showing a combined extrusion and slide hopper by means of which three layers of coating material may be applied in accordance with the present invention.

As pointed out above, in the manufacture of supports or continuous webs which require the application of two or more separate coatings in superposed layer relationship on one surface, it is the customary procedure to place each of the coatings on the support in succession and to allow each coat to dry before applying the next. Such a procedure has been deemed necessary in order to maintain a distinct relationship between the separate layers and to prevent mixing of the coating or contamination of one by the other at the interface of the layers. It will be appreciated that such a procedure of applying a plurality of coatings to a surface of the support has been very time consuming and has involved the use of duplicate equipment for each coating. These two factors alone have added greatly to the expense of making such multiplicity coated supports.

While there are a great many different instances in which it is necessary or desirable to place two or more coatings in layer relationship on the same surface of a web or support, a classic example, and one which will be used by way of specific illustration in disclosing the present invention, is the manufacture of light-sensitive products, such as photographic film and/or paper.

In the manufacture of photographic film and paper there are usually at least two separate coatings applied to the surface of a support, and in the case of color sensitive products, this number of coatings runs as high as eight or more. In the case of color films these separate coatings may include three separate silver halide emulsions, one sensitive to a different wave-length, light filtering layers, subbing layers, a protective layer, etc. In the application of certain of these layers, it may be necessary that there be no contamination or mixing at the interface and the thickness of the different layers may be critical. Likewise, the order in which the layers are applied to the support is important. In order to satisfy all of these requirements, the customary procedure of applying these coatings has been to apply them one at a time in succession and setting and drying each coating before applying the succeeding one. These coatings are usually applied by putting the different materials in solution and coating them in this form, by any number of different techniques, onto a continuously moving support. One well-known coating technique involves the use of a hopper to the mouth or lips of which the solution is fed at a fixed rate, depending upon the thickness of coating desired, and from which the stream of coating from a bead formed between the hopper mouth or slot and the support.

The present invention is concerned with the discovery that two or more of these coatings can be applied to a support simultaneously and still maintain a distinct relationship. The different materials coated according to the present invention, although coated in the form of solutions, do not show any more contamination or mixture at the interface of the layers than the same materials when coated in succession by the customary technique which involves a complete setting and drying of each coat before the next is applied. By this novel method of coating the desired individual thickness of each layer of coating material can be applied to the same extent as when the coatings are applied separately. Furthermore, this method is particularly suitable for applying thin coatings, or coatings having a dry thickness of from less than one micron to 0.025 inch. This phenomenon is not limited to the coating of different coating materials and which in coating composition are non-comparable, but is apparent when the separate coatings are of the same material. It is this fact that makes the present method valuable in applying the different coatings of a photographic film, since each of the separate coatings in such a product are essentially water-permeable gelatin solutions differing only in the silver salt, the dye, or other materials, suspended or dispersed therein. For best results, of course, it is desirable to include a coating aid such as saponin, an alkyl sulfate, etc., in the coating compositions.

In its broadest aspects this method of coating involves putting the materials to be coated in solution and simultaneously applying the several coating solutions at the same point to a support moving relatively to the point of application. One way of accomplishing this is to simultaneously feed the several coating solutions into a bead across, and in contact with which, the support to be coated is continuously moved. As a result of the several coating materials will be distinct and the thickness of the layers will be dependent upon the rate at which the solutions are individually fed to the bead.

The present invention relates to my discovery that a plurality of the same or different fluid coating compositions can be applied to the surface of a web or support in distinct layer relationship by feeding a layer of each of the compositions from a suitable coating device and combining said layers in the proper orientation prior to their being simultaneously applied to the web or support in such combined relationship. Experiments have shown that by this method of applying multiple layers of coating compositions that there is substantially no more contamination or mixing between the separate layers at their interface than there would be if the usual technique were used. Furthermore, it has been shown that this phenomenon is not dependent upon the different coating compositions having incompatible characteristics, but holds true especially when two layers of the same coating composition are simultaneously applied to the coating support. The broad method of multiple coating is not dependent upon the use of any particular coating apparatus so long as it permis the formation of each of the coating compositions into a layer of desired thickness and then permits these layers to be brought into surface contact in the desired orientation and to be fed to the surface of the support in such a combined relationship. A coating technique which has been found particularly applicable to this method of coating is the so-called bead method of coating since the combined layers of different coating composition can be fed into the bead from a suitable coating device and then be simultaneously picked up on the surface of a support moved across and in contact with said bead.

The bead method of applying coatings to a moving web is well known in the art and needs little explanation. Normally it involves the use of a coating device, i.e., a hopper, from which the coating solution is fed at a known rate in the form of a wide, thin ribbon onto the surface of a web moving across the exit slit of the coating device and spread out by some sort of backing roll or guiding surface which serves to hold the web smooth at this point of application. The layer of coating solution leaving the coating device, instead of coating directly onto the web in a layer having a thickness equal to that leaving the coating device, tends to pile up or "puddle," on that...
side of the coating device from which the web departs. This pile up or "puddle" of coating solution extends completely across the web from the coating device, but the coating device merely maintains the coating bead and the web is coated therefrom. With the bead method of coating the thickness of the coating laid down on a web moved thereacross will be determined by the action of the bead and will vary with the speed of web movement, the rate of the distillation, the layer relationship, being maintained in the coating bead and will not necessarily be equal to the width of the exit slot of the coating device. Throughout this specification and the claims associated therewith, therefore, the term "coating bead" will be used to mean a "puddle" or pile up of coating solution maintained in bridging relation between the surface of the web and a coating device which is stationary relative to the bead of coating and spaced transversely from the support and access and in contact with which the surface of a web is moved to be coated therefrom. By the same token, the term "bead coating" will refer to that method of coating a web a web where the surface thereof is moved across and in contact with a coating bead and takes up the coating therefrom.

In Figs. 1 and 2 there is shown an apparatus which was successfully used to prove that this principle of coating at least two layers simultaneously onto a support was sound. Here there is shown a dual-feed coating hopper 10 having an exit slot 11, the lips 12 of which are slightly spaced from the surface of a web W backed up by a roll 13 which may serve to continuously move the web past the hopper slot. One coating solution S is continuously fed into an upper inlet 14 by a suitable metering pump P whereas the second coating solution S' is continuously fed into the lower inlet 15 by a separate metering pump P', see Fig. 2. An adjustable baffle 16 divides the interior of the hopper into two separate cavities and serves to direct the two solutions in the form of thin layers L and L' toward the hopper slot 11. The hopper was made of a transparent plastic material and differently colored coating solutions were used so that the behavior of the solutions could be watched and it was obvious that the layer L of solution S coming into the upper inlet was on top of the layer L of the solution S' coming into the lower inlet throughout the entire length of the exit slot 11. When the combined layers of solutions reached the coating bead 17 between the hopper lips and the web W, the superposition was maintained in the bead, despite apparent deformation of the bead, and an enlarged cross-section of the coated web after being dried showed that the two layers were distinct, extremely free of contamination or mixing at their interface, and possessed a relative thickness comparable to the rate at which each solution was pumped into the hopper.

The hopper 10 may be provided with any suitable form of adjustable mount so that the position of its exit slot 11 relative to the surface of the web W being coated can be adjusted for the best coating procedure. To this end, the hopper is carried by a frame 18 provided with bearings 19a rotatably journalled on the axle 8 of the backing roll 13 to permit the mount to be swung concentrically of the backing roll 13 so that the position of the hopper as a whole may be shifted around said roll. The frame 18 is capable of being locked in any adjusted position by means of a clamping screw 7 engaging an arcuate slot 6 in the frame. The colored gelatin was pumped into the frame 18 at 20 so that the angle of the exit slot 11 may be critically adjusted relative to the surface of the web to be coated by means of adjustment of screw 5. To permit adjustment of the hopper to and from the web W to vary the distance between the web and the ends of the hopper lips, the hopper is slidably mounted on the frame 18 and connected with an adjusting screw 21. After the web W has been coated, it is necessary to allow and/or to vary the coatings applied thereto. In the manufacture of photographic film or paper the coatings applied may be of the type which are set by cooling prior to drying in order to limit the amount of relative flow between the layers and the lower layer and the surface of the support. In such a case the web W after being coated and then passed through a chill chamber 22 and then through a drying chamber 23, after which it is taken up on a wind-up roll 4. If the coatings applied do not require chilling before drying, then chill chamber 22 may be omitted or by-passed.

Referring to Figs. 2 and 3, it will be seen that the coating composition S entering upper inlet 14 is formed into a layer upon passing between the end of the baffle 16 and the upper inclined wall 24 of the hopper. Likewise, the coating composition S' entering the lower inlet 15 is formed into a layer upon passing between the end of this baffle 16 and the lower inclined wall 25 of the hopper. These two layers are then brought into surface contact just prior to, or upon, entering the exit slot 11 of the hopper and are then directed by this hopper in this combined relation into the coating bead 17 where in they maintain the desired distinct layer relationship, as indicated in Fig. 3, and from which bead the layers are simultaneously coated on the surface of the web in the desired layer relationship. It is pointed out that the width of the exit slot 11 is not equal to the combined thickness of the layers of coating composition directed thereto, but is preferably equal to the thickness of one of said layers or may even be less than this. This means that the velocity of the combined layers L and L' passing through the exit slot 11 must be greater than that of the individual layers as they approach the slot, i.e. double if the two layers are of equal thickness and the compositions of which the layers are formed are being pumped into the hopper at the same rate. It should be pointed out that it is not the width of this exit slot 11 or the width of the slots forming the individual layers which determine the final thickness of the layers as they are applied to the web. This final thickness (wet) will be determined by the bead action and will vary with the velocity of the web, the rate of supply of the coating compositions, the efficiency of the hopper structure, etc. The relative widths of the slots forming the individual layers of the different coating compositions must be such as to permit the proper amount of the different solutions to be fed to the bead as determined by the bead laydown, and the rate at which the different compositions are pumped will be determined by the relative thickness of the two layers desired on the web. For example, if the coating S applied is to be twice as thick as coating S', then the slot widths are not varied, but coating S is pumped into the hopper at a rate twice that of coating S'.

Experiments have shown that the types of coating compositions which can be applied by this method, as well as the relative thicknesses of coatings, the speed of coating, the velocity of the coating composition, etc. are apparently without limit in a practical sense of the word. In one test of this disclosed dual-feed hopper a coarse grain silver bromide emulsion web was coated with the lower inlet 15 and a nondiffusing colored gelatin solution was pumped into the upper inlet 14. The emulsion was pumped into the hopper with a metering pump from a melt at 53.5 pounds per silver mole for a coverage of approximately 170 square feet per silver mole. The colored gelatin solution was pumped into the lower inlet 15 and a nondiffusing colored gelatin solution was pumped into the upper inlet 14 by a metering pump from a solution containing about seven percent dry gelatin. Both pumps were driven simultaneously with a commercial metering unit. Two coatings were made on a cellulose acetate support, one at twelve feet per minute and the other at eighteen feet per minute and in each case the two layers were
simultaneously set and dried by conventional equipment. Enlarged cross-sections of the dried films showed excellent separation of the gelatin and light-sensitive emulsion layers, and indicated that the relative thickness of the two coatings was directly proportional to the rate at which the films were pumped into the hopper. Although the speed of coating in one instance was 50 percent greater than in the other, there was no indication that the speed of coating had any adverse effect on the distinct layer characteristics of the applied coatings.

In another experiment the colored gelatin of the above experiment was replaced with a seven percent clear gelatin solution and pumped with a smaller pump. Here again cross-sections of the films showed excellent separation of the gelatin and emulsion layers.

In order to determine whether this coating principle might also be satisfactory for the application of light-sensitive emulsions used in the manufacture of color print material, the following coatings were made on a cellulose acetate support using the dual-feed hopper of Figs. 1–3 and producing a coated product shown in Fig. 4. A coated product comprises a support or web W of cellulose acetate having successive layers of a blue-sensitized silver chlorobromide emulsion B, a red-sensitized silver chlorobromide emulsion R, a green-sensitized silver chlorobromide emulsion G and a clear gelatin layer C, in that order. Since only a dual-feed hopper was used, the first two emulsions R and B were applied simultaneously and the third emulsion and the clear gelatin layers G and C, respectively, were applied simultaneously atop the first two layers after they were completely dried.

In making this color print coating the blue-sensitized emulsion contained 5.6 percent gelatin and a yellow coupler and was coated at the rate of 16.72 pounds per square mole and 1.78 pounds per 100 square feet giving a coverage of 940 square feet per square mole. The red-sensitized emulsion contained 5.6 percent gelatin and a cyan coupler and was coated at the rate of 21.50 pounds per square mole and 1.78 pounds per hundred square feet giving a coverage of 1200 square feet per square mole. The green-sensitized emulsion containing 5.6 percent gelatin and a magenta coupler and was coated at the rate of 17.1 pounds per square mole giving a coverage of 965 square feet per square mole. The clear gelatin W which contained seven percent gelatin was coated at the rate of .89 pound of solution per hundred square feet.

Visual inspection of cross-section studies of these coatings showed no greater contamination between the individual layers than for layers of the same materials applied one layer at a time as in conventional practice. In addition, photographic tests of this color print material coated with a dual-hopper showed as good results as the same material coated one layer at a time in the conventional way.

In order to ascertain whether or not three coatings could be applied according to this coating principle, a triple feed hopper of the type shown in Fig. 5 was constructed. This hopper 26 has an exit slot 30, the lips 32 of which are slightly spaced from the surface of a web W backed by a roll 13 which may serve to continuously move the web past the hopper slot as before. The coating material S’ which is to be the bottom layer L’ was pumped into the lower inlet 33, the coating material S which was to be the center layer L was fed into the intermediate inlet 34, and the coating material S which was to be the top layer L was fed into the top inlet 35. The three coating materials were then directed toward the upper exit slot 30 by layer forming slitos 36, 37 and 38, respectively, and the three layers formed upon passage through these slots flowed in combined relation through said exit slot 30 in the proper stratified relationship. In this case the width of the intermediate layer L’ will be less than that of the outer layers because the average velocity of the middle layer is higher than the average velocity at the edges due to friction between the outer layers and the faces of the exit slot. This stratified relationship of the different layers is maintained in the coating bead 17 between the hopper lips and the web W so that the three different coating materials are deposited simultaneously onto the web in the proper layer relationship as the web moves across and in contact with the bead.

In an effort to determine the exact form of the coating bead 17 and just what sort of paths the three separate layers of coating composition assume in passing through the bead, several different techniques were used, including photography, direct visual inspection with a 5X magnifier, etc., without much success. While it was possible to ascertain the general shape of the exterior of the bead, it was practically impossible to obtain an accurate determination of the paths taken by the individual layers, even when differently colored solutions were used, because at the edge of the bead the uppermost layer or layers tended to flow down over the others and obscure a view of the separate layers. Accordingly, while it is impossible to accurately depict the relationship of the different layers of coating solutions during their passage through the bead, I have shown in Fig. 5 what is believed to occur in this connection. It is believed that the uppermost layer of solution piles at the edge of the nozzle due to capillary attraction and/or surface tension, that the middle layer of solution passes through the bead with little deformation, and that the lower layer of solution backs into and fills the space between the end of the lower lip and the web W due to capillary attraction and/or surface tension, as indicated in Fig. 5. It is known that the form of the bead, and probably the path of the individual layers moving therethrough, will vary rather widely with the speed of coating, the viscosity of the coating solutions and the efficiency of the hopper construction. Notwithstanding the fact that this conception of the bead form, and the form of the individual layers passing therethrough, may not be correct, it has been unquestionably proven by the inspection of magnified cross-sections of materials coated in this manner that the individual layers of different coating solutions pass through the bead in a regulated manner without mixing and that a multilayer material coated according to this technique shows no more mixing or contamination between the layers than would be experienced by using the conventional coating techniques where each material is laid down in succession with complete drying between laydows.

This triple feed hopper was tested in making the four layer experimental color print coating described above. In this experiment, the blue, red, and green-sensitive emulsions were applied simultaneously as superposed liquid layers in the order specified and at a coating speed of approximately twelve feet per minute. After coating, the emulsions were set and dried simultaneously by means of apparatus substantially like that disclosed in Fig. 1, and the clear gelatin overcoat was applied separately and set and dried. A check coating was then made of these same materials by coating each material individually in the conventional manner. When these two multilayer coatings were exposed to a series of neutral and colored step wedges and processed in a conventional color developer, the photographic tests of the two appeared identical, the coating quality being excellent. This test indicated that there was no more mixing or contamination between the separate layers when they were applied simultaneously than when they were applied separately and this fact was further proven by the inspection of enlarged cross-sections of the two coatings.

Having found that two or three different coating materials could be simultaneously applied to a web and still maintain a distinct layer relationship with no considerable or noticeable contamination or mixing at the inter-
face of the layers, the question arose to what, if any, is the limitation as to the number of different coatings which might be applied in accordance with this coating principle.

Accordingly, a four-tube, multifeed hopper of the type shown in Figs. 6–8 was constructed and it was determined that four different coating materials could be simultaneously applied to a web and still maintain a distinct layer relationship between the coatings. This hopper is composed of a top section 40 and a bottom section 41 which are held in assembled relation by two end plates 42 and 43 fastened to the top and bottom sections by bolts 44. The forward edges of each of the top and bottom sections are spaced from one another to provide an exit or discharge slot 45 which extends across the width of the hopper and whose width is defined by end plates 42 and 43. The bottom section 41 is provided with a recess or chamber 46 communicating with the exit slot of the hopper by a curved convex surface 47. The hopper chamber is divided into four sections by three dams 48, 49 and 50 which extend entirely across the width of the hopper chamber 46. Each of these dams includes a concave curved surface 51 and a convex curved surface 52 which cooperate with one another in opposite pairs to form gradually restricted flow passages 53, 54, 55 and 56 which cause coating solutions pumped into the enlarged portions thereof to be forced out across the hopper end to be forced in thin streams or layers toward the hopper discharge slot 45. The convex surfaces 52 and the front wall 47 of the hopper chamber 46 each terminate in a substantially flat surface 57 or 58 which is spaced from the lower face of the upper hopper section 40 by a form discharge slots 59, 60 and 61 for forming the separate coating compositions into layers of regulated thickness and which layers are directed to the discharge slot 45. In order to facilitate assembly and to regulate the thickness of the individual layers of the different coating compositions in the hopper, each of the dams 48, 49 and 50 is made adjustable by means of a pair of adjusting screws 62 and set screws 63. By adjustment of screws 62 the width of each of the discharge slots 59, 60 and 61 can be regulated to the desired extent, and after the desired adjustment has been made, the set screws 63 are adjusted to lock the dams in such positions. Each of the four flow passages has connected thereto a nipple 64 onto the end of which one of four feed tubes 65, 66, 67 or 68 may be slipped. Each of the four feed tubes is connected to a supply of a different coating solution and from which stationary coating solution can be pumped into the hopper by separate metering pumps at rates commensurate with the thickness of the particular coating layers desired in the final laydown.

I have found that if four different coating solutions are fed into the hopper through feed tubes 65, 66, 67 and 68 that they will be formed into four layers which will pass through the exit slot 45 of the hopper in distinct layer relationship and will be so deposited on a web W providing the web is fed across and in contact with a bead of the solutions into which the combined layers issuing from the tips of the discharge slot are constantly fed. If the web is moved in a counterclockwise direction, looking at Fig. 8, then the layer of coating solution entering feed tube 65 will be deposited directly on the web surface, that entering feed tube 66 will lie upon the layer of coating solution from tube 65, that entering feed tube 67 will lie upon the layer of coating solution from tube 66, and that entering feed tube 68 will be the outermost layer. No attempt has been made to show in Fig. 8 the flow of the four separate layers of different coating compositions onto the web because of the small scale of that figure. However, in the enlarged detail section of Fig. 6A, the manner in which the four separate compositions pass through the extrusion slot of this four-tube hopper and into the coating bead for subsequent pickup by the web is illustrated to the best of applicant's knowledge. If the direction of the feed of the web W across the bead is reversed, then the relationship of the layers of coating solution will be reversed on the web. As pointed out above, the relative thicknesses of the individual layers of the different coating solutions deposited on the web W will depend not upon the width of the slot formed by the several dams and the upper section of the hopper but will depend upon the rate at which the respective coating compositions are pumped into the hopper. I have found that the above-mentioned orientation of the layers of coating solution will not be affected by the order in which the pumping of the different solutions into the hopper is started.

This four-tube multifeed hopper was tested and proved by making a multiple coating of black and clear gelatin on a web of photographic support in the following manner. For this test the black gelatin was prepared by dispersing 2450 grams of a 3.7 percent black gelatin containing a metallic silver dispersion in 5500 grams of ten percent photographic gelatin plus 1070 cc. of distilled water. The clear gelatin coatings were made from a solution of 6810 grams of ten percent photographic gelatin plus 2850 cc. of distilled water. Twenty cc. per liter of a 7½ percent saponin solution were added to each coating solution to act as a coating aid.

The coatings were made by applying the black gelatin in the first and third layers and the clear gelatin in the second and fourth layers. With the hopper shown in Figs. 6–8, this meant feeding black gelatin into feed tubes 65 and 67 and the clear gelatin into feed tubes 66 and 68 and running the web W in a counterclockwise direction as indicated. After these coatings were set and dried, a photomicrograph of a cross-section of the multiple coating showed that all of the coats applied satisfactorily and that each layer was oriented in the proper relation. Furthermore, there appeared to be no mixing or contamination of the individual layers.

Having proved that there is apparently no limit to the number of separate coatings which can be simultaneously applied to a support by the method of coating, a series of tests were made to determine what limits, if any, there might be to the type of coating solutions which could be simultaneously applied to a support by this coating principle and still maintain a desired distinct layer relationship between coatings.

Two polynvinyl alcohol solutions, one a polynvinyl alcohol light-sensitive emulsion and the other a clear polynvinyl alcohol solution, were prepared and coated on a polynvinyl alcohol subbed cellulose acetate support at approximately twelve feet per minute. The triple feed hopper shown in Fig. 5 was used in this test with one of the chambers blanked out so that only two layers could be coated simultaneously. The light-sensitive emulsion was a silver bromide emulsion in four percent polynvinyl alcohol at pH=6.0, containing 60 cc. 7½ percent saponin solution and 160 cc. four percent borax solution at pH=5.5. The clear polynvinyl alcohol solution was a six percent clear polynvinyl alcohol solution containing 95 cc. 7½ percent saponin solution and 250 cc. four percent borax solution per pound of polynvinyl alcohol. The light-sensitive solution was coated directly on the support at 3.0 pounds per hundred square feet and this was overcoated with 1.5 pounds per hundred square feet with the clear polynvinyl alcohol solution. After coating, these layers of coating material were set at room temperature by fuming with ammonia as described in U. S. Patent No. 2,376,371. Cross-sections were made of this coating, and under the microscope two distinct layers were visible and no apparent mixing of the two layers appeared to have occurred.

Commercial polynvinyl alcohol is hydrolyzed polynvinyl acetate having approximately 5% acetate. It is readily dissolved in water at ordinary temperature and behaves like a typical reversible colloid. Gelatin likewise is readily soluble in warm water and is a colloid. Accordingly, the experimental coatings made show that this principle...
of simultaneously coating layers of separate coating materials onto a support is applicable with colloidal material which can be put into solution.

Also an example of a three-layer coating which was made in accordance with the present invention using the triple feed hopper shown in Fig. 5 is as follows: In this example, the top coat consisted of a seven percent gelatin solution containing a yellow colloidal silver dispersion and 270 cc. of a seven and one-half percent saponin solution per pound of gelatin. The middle coat consisted of a seven percent gelatin solution containing 60 cc. of a seven and one-half percent saponin solution per pound of gelatin. The bottom coat consisted of a seven and one-half percent gelatin solution containing a black metallic silver dispersion and 60 cc. of a seven and one-half percent saponin solution per pound of gelatin. All three coats were applied simultaneously onto a clear cellulose acetate support at a coverage of 1.78 pounds per hundred square feet for each layer and at a coating speed of twelve feet per minute. Excellent separation of the layers was obtained, as shown by photomicrographs of a cross-section of this coated web. The saponin solution had no effect on the phenomenon of the layers maintaining desired distinct relationship during and after coating, but it was introduced into the different coating compositions to increase the spreading characteristics thereof so that they would more readily spread and produce an even coating. To find out what effect the speed of coating might have on this principle of multiple coating, a coating was made using the same apparatus and coating compositions as set forth in the immediately preceding example, except that the coating speed was eighteen feet per minute rather than twelve feet per minute. It was evident from an inspection of a photomicrograph of a cross-section of the coated support after drying the coatings that excellent separation of the layers was also obtained at this coating speed and it differed from the first example only in that each of the layers were approximately ½ as thick as when coated at twelve feet per minute.

That this method of coating is applicable to the multilayer coating of colloidal materials other than gelatin and polyvinyl alcohol is evidenced by the following example: The colloids used in this test was cellulose ether phosphalate comprising an ethyl cellulose, having an ethoxy content of approximately 45 percent phosphalated according to the method described in U. S. Patent 2,093,452. A gelatinized cellulose ether phthalate having an apparent phthalate content of 16.8%. In this test the ethyl cellulose phthalate employed as a coating composition was in the form of its salt, such as ammonium salt, which is water soluble and two layers of this material were applied, according to this invention, onto a clear cellulose acetate support with a coverage of 1.25 pounds per hundred square feet and at a coating speed of six feet per minute. The top layer was coated from a clear solution of cellulose ether phthalate salt and the bottom layer contained one part of carbon dispersion (Aqua Black, made by Binney-Smith) to nine parts of the cellulose ether phthalate. The carbon dispersion was added to one of the coating compositions merely to show whether or not the two materials coated in distinct layer relationship without contamination or mixing at the interface of the layers. Photomicrographs of a cross-section of the web so coated showed clearly that good separation of the layers was also obtained with these coating compositions.

The following example points out that it is possible to simultaneously coat two layers of coating composition in accordance with the present invention which are not colloidal materials and still obtain good separation between the layers. In this example two layers of a polymeric hydrosol were coated with good results. In this case, of course, the particles are not peptized in a colloid, as was the case in the above examples, but the coatings composition consisted of a dispersion of polymeric particles in water. These coatings were applied with the triple feed hopper shown in Fig. 5 set up for dual application, that is, the middle section was blocked off and the coating solutions were applied through the top and bottom inlets. In order to obtain a polymeric hydrosol for this test, a commercially available aqueous dispersion of an acrylate resin sold under the trade-name Rhoplex was used. Rhoplex is manufactured by Rohm & Haas and is believed to be an acrylate acrylonitrile polymeric hydrosol. In another test a smooth, uniformly thin layer of an acrylate and acrylonitrile in water. The top coat was made of clear Rhoplex whereas the bottom layer was made of Rhoplex to which a was added an aqueous dispersion of carbon particles merely to show the separation of the two layers. Both layers were coated at a coverage of 1.25 pounds per hundred square feet and at a rate of six feet per minute. After these layers were deposited on the support, the water was evaporated whereupon the particles of the polymeric hydrosol coalesced and formed continuous layers of the polymer. A photomicrograph of the dried coating showed excellent separation between the clear and black layers of polymers deposited on the web. This novel method of multiple coating a web is not limited to the use of extrusion type hoppers already disclosed, but can be successively carried out, even with certain advantages, with other types of coating devices. This method of coating may be readily carried out by the use of a multiple slide hopper of the type disclosed in copending U. S. application Serial No. 489,969, filed on even date herewith in the names of Mercier, Torpey and Russell. In Fig. 9 there is shown a double slide hopper by the use of which a dual coating may be made in accordance with the present invention. With this hopper, one fluid coating composition 74 is continuously pumped by a metering pump P into a cavity 75 at a given rate through inlet 76 and from which it is forced through a narrow vertical slot 77 in the form of a ribbon and out onto the downward inclined slide surface 78 down which it flows by gravity in the form of a layer 79 to a point where it forms a coating bead 17 between the end of the slide surface and a web W moved upwardly across and in contact with the bead by a supporting roll 13. The second coating composition 80 is continuously pumped into a second cavity 81 at a given rate by another metering pump P through inlet 82 and from which it is forced through a narrow vertical slot 83 in the form of a ribbon and onto a second downwardly inclined slide surface 84. This ribbon of the second coating composition in flowing down the slide surface 84 under the influence of gravity forms a smooth, uniformly thick layer 85. The two slide surfaces 78 and 84 are coplanar, or substantially so, so that as the layer 85 of the second coating composition reaches the ribbon of the first coating composition being extruded through slot 77, it flows up on top of the same and the two then flow together down slide surface 78 and into the coating bend 17. The relative thickness of the two layers of coating material will depend upon the rate at which they are pumped into their respective cavities 75 and 81. The hopper is provided with pipes 86 through which hot or cold fluids can be circulated to keep the coating composition in a desired fluid state.

Using a double slide hopper of this type, a gelatin silver halide photographic emulsion and a protective coat of 'clear' gelatin have been simultaneously coated onto a baryta-coated paper 40 inches wide at a speed of 100 feet per minute to produce a commercial photographic paper having as good characteristics as the same product having the two coatings applied successively and with a complete drying of the emulsion coat prior to application of the protective gelatin coat. To obtain optimum conditions at this coating speed, it was found desirable to use a vacuum on the back, as is described in U. S. Patent 2,681,294. This example clearly shows that this method of coating is not limited to the coating of narrow width sheets and at slow coating speeds, but is equally adapted
for the coating of commercial width product at high coating speeds.

In Fig. 10 there is shown a four slide hopper by the use of which four separate layers of the same or different coating compositions may be simultaneously applied to the surface of a web in accordance with the present invention. In this device the first coating composition is continuously pumped at a given rate into a cavity 90 from which it is extruded through a narrow vertical slot 91 out onto a downwardly inclined slide surface 92 over which it flows by gravity to form a layer of that composition. Likewise other coating compositions are continuously pumped into chambers 93, 94 and 95 and are extruded from narrow vertical slot 96, 97 and 98 respectively onto slide surfaces 99, 100 and 101, respectively, down which they flow by gravity to form separate layers of the different compositions. The four slide surfaces are coplanar so that as the layers of different coating compositions flow down their respective slide surfaces they are brought together in overlapping relation and by the time the four layers reach the coating bead 177, they are combined in the desired laminated relationship. This distinct layer relationship is maintained throughout the bead so that as the web W is moved across and in contact with the bead, it takes up on its surface the four layers of coating in the desired orientation and with the layers being distinctly separate from one another and of a relative thickness commensurate with the rate at which each was pumped into the hopper. So far as I have been able to ascertain, there is no limit as to the number of separate layers of coating that may be disposed in copending U. S. application Serial No. 489,846, filed on even date herewith in the names of Wilson, Sanford and Russell.

In Fig. 11 a hopper is shown which combines a single slide hopper with a single extrusion hopper in accordance with the Wilson et al. disclosure. In this device one fluid coating composition X is continuously pumped into a chamber 110 and is extruded therefrom as a layer 111 from a substantially horizontal extrusion slot 112 directly toward the coating bead 177 across and in contact with which the web W is moved in the direction of the arrow while passing around roll 113. The other coating composition Y is continuously pumped into chamber 114 at a given rate and is extruded as a ribbon through substantially horizontal slot 115 onto a downwardly inclined surface 115. As this ribbon of solution flows down the slide surface 115 by gravity, it is formed into a layer 116 of desired thickness and is brought into surface contact with the layer 111 of the other coating composition at the time it leaves extrusion slot 112 so that they move into the coating bead in combined relation. In accordance with the present invention, these two layers of coating composition are picked up by the web W and appear on the web, after drying, as two separate and distinct layers oriented so that the layer 111 extruded through slot 112 lies directly on the surface of the web and the layer 116 formed on the slide surface lies on top of layer 111.

In Fig. 12 a hopper is shown which combines a single slide hopper with two extrusion hoppers in accordance with the Wilson et al. disclosure, and by the use of which a triple coating may be made on a web in accordance with the present invention. In this device one coating solution Z is continuously pumped into a chamber 120 and is extruded as a layer 121 from an upwardly inclined slot 122 directly toward the coating bead 177 across and in contact with which the surface of a web W is moved in the direction of the arrow while passing around backing roll 123. A second coating solution Z" is continuously pumped into chamber 124 from a substantially horizontal slot 125 directly toward the coating bead. The third coating solution Z' is continuously pumped at a known rate into chamber 126 and is extruded as a ribbon through a substantially horizontal slot 127 onto a downwardly inclined slide surface 128. As this ribbon of solution flows down the slide surface 121, it is formed into a layer 129 of desired thickness and smoothness. It will be observed that the extrusion slots 122 and 125, and the lower end of the slide surface 128, are so disposed that the third coating solution formed individually thereby or thereon, as the case may be, are brought together in surface contact with one another just prior to the three layers entering the coating bead and prior to being applied to the web. The three layers thus pass into the bead and are coated on to the web in distinct and separate layer relationship and are so oriented that the layer of coating solution Z is adjacent the web, the layer of coating solution Z' is directly on the layer of coating solution Z, and the layer of coating solution Z" is the outermost of the three and in surface contact with the layer of coating solution Z'. A feature which distinguishes this form of hopper from the hopper shown in Figs. 2 and 3 is that each hopper chamber has its own extrusion or distributing slot (122 and 125) so that the layers of the individual coating solutions do not meet until after passing from the slots. This shows that the present method of multiple coating is not limited to forming and bringing the individual layers together a substantial period of time before they are introduced into the coating bead, but that the individual layers can be combined just prior to, or at the time, they enter the bead and the desirable results of obtaining a multiple layer application with distinct layer relationship will still be achieved. These combined slide and extrusion hoppers have been successfully used to simultaneously apply different types of commercially used gelatino silver halide light-sensitive emulsions and protective coats of gelatin, and to simultaneously coat the light-sensitive color emulsions used in the making of color photographic films mentioned above in discussing the dual and triple extrusion hoppers shown in Figs. 3 and 5. In each instance the product multiply coated with this method was as good in all respects, both physical and chemical, as a product coated in the conventional way by applying the different coatings successively with complete drying between each coating. These hoppers have been successfully used to coat webs 441 inches wide at speeds of coating ranging all the way from 24 feet per minute to 100 feet per minute.

I am unable to explain why two or more layers of coating composition when simultaneously coated onto a web in accordance with the present invention do not mix but maintain a layer relationship as distinct and as free of mixing and contamination at the interface of the layers as when the same compositions are coated successively with a complete drying of each coating before the next one is applied thereto. It is not based on the fact that the different coating compositions are physically or chemically non-compatible because, as the example shows, the same results were obtained when all of the coating compositions were identical both physically and chemically, except that a dye or carbon dispersion was incorporated in one to give visible proof of this phenomenon. In attempting to explain the reason why the different layers of coating composition do not mix when coated according to the present invention, the question of whether it was because a form of liquid motion known as "laminar flow" was involved as distinguished from a form of motion which turbulent motion has been considered. According to the Reynolds' theory of fluid mechanics, "Fluid Mechanics," Prentice Hall, 1943, p. 71, when two separate streams of water are passed through a pipe, they will stay separated due to a condition of laminar flow so long as the critical velocity is not reached.
and after the critical velocity is reached, the flow becomes turbulent and the streams will mix. Reynolds showed that the critical velocity depended on the diameter of the pipe, the velocity of the fluids passing through the pipe, its density, and its viscosity, and that if these four factors were combined in one way only, a function known as the Reynolds number would be obtained giving the critical velocity for the flow of a fluid through a pipe. While this theory might be applied to explain the reason why the separate layers do not mix in passing in combined relation through the exit slot in one of the disclosed extrusion type hoppers, on the basis that the flow is laminar because the Reynolds number is not high enough to reach the critical velocity, it does not seem to apply when the multiple slide hopper or combined slide and extrusion hopper techniques are used, nor does it explain the maintained separation of the layers through the coating bead and after disposition on the web until they are dried, because the layers are not moving through a pipe nor are they totally confined in any way. The one explanation for this phenomenon which might be advanced is that normally it takes an appreciable time for two solutions to mix even if they are brought together in such a way as to provoke turbulence, and with applicant's method of coating the different layers are not in combined layer relationship long enough, before being deposited on the web, to allow noticeable mixing to take place even if the conditions of flow are such as to be conducive to such a mixing. As to why the layers of coating maintain their separate relationship between the time they are deposited on the web and they are completely dried is inexplicable except in the case of those coating compositions which are capable of being set by chilling, heating, or by chemical action immediately after deposition on the web surface and prior to drying. By the time the gel is dried again the element of time might be the critical factor since the time elapsing between the deposition of the layers on the web and the time the coating is dried is relatively short and perhaps less than the time required for the coatings, or the materials dispersed therein, to diffuse into one another.

I have found that my novel method of multiple coating makes it possible to carry out this idea of chemically setting such coating solutions in a more direct and convenient manner without the need for the use of ammonia in gaseous form and without the problem incident to subjecting a freshly coated web to such a gaseous treatment without the danger of roughening the surface of the coating due to the injection of gas under pressure onto such a fresh coating. With the present method of coating, if two different protein coating solutions are being applied to a support and an aldehyde, e.g. formaldehyde, is introduced into one and ammonia is introduced into the other, then when the two layers come together at the time of coating the ammonia and formaldehyde presumably diffuse throughout both layers causing them to set simultaneously.

The following coatings were made and showed this chemical setting took place without in any way affecting the distinct layer relationship of the two coatings laid down on the support. Two coating solutions (1) a silver bromocresol emulsion containing 60 cc. 7½% saponin and 20 cc. of 10% formaldehyde per silver mole at pH=6.0 and 7% dry gelatin and (2) a 7% clear gelatin solution containing 60 cc. 7½% saponin and sufficient amount of NH₄OH to raise the pH to 8 were first simultaneously coated by the use of the dual hopper shown in Fig. 2 at approximately 12 feet per minute with the emulsion directly on an acetate support. The emulsion was coated at a rate of 3.0 lbs./100 square feet and the gelatin solution was coated at a rate of 1.5 lbs./100 square feet on top of the emulsion layer. In another run the same materials were coated the same as in the first run but with the layers reversed, i.e. with the emulsion on the wet gelatin layer. In a third run the two film materials were coated the same as in the first run but with the gelatin solution at pH=9.0. All of these experiments gave good separation of the two layers even though the formaldehyde and ammonia diffused freely between the two layers to chemically set them in very short order.

While I have shown and described certain specific embodiments of my invention, I am aware that many modifications thereof are possible. My invention, therefore, is not to be limited to the precise details shown and described but is intended to cover all modifications coming within the scope of the appended claims.

Having thus described my invention, that I claim is new and desire to secure by Letters Patent of the United States is:

1. The method of simultaneously applying thin coatings of a plurality of colloidal materials onto a web support in distinct layer relationship comprising the steps of making a solution of each of said materials, forming a coating bead of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bead and in superposed relationship to the other solutions whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bead so that the surface of the support engages one of the outermost of the superposed layers in said bead and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers.

2. The method of simultaneously applying thin coatings of a plurality of colloidal materials onto a web support in distinct layer relationship comprising the steps of making a solution of each of said materials, forming a coating bead of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bead and in superposed relationship to the other solutions whereby the individual layers are maintained in distinct superposed relation, and regulating the relative rate of flow of said solutions into said bead commensurate with the relative thickness of the layers of each material desired on said support, and continuously moving the surface of said support across and in contact with said bead so that the surface of the support engages one of the outermost of the superposed layers in said bead and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers having a thickness varying in direct proportion to the rate feeding each of said solutions in the form of a layer into said bead and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation.
aneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers.

4. The method of simultaneously applying thin coatings of a plurality of polyvinyl alcohol solutions onto a web support in distinct layer relationship comprising the steps of forming a coating bed of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers and moves away from the bead with the solutions in distinct superposed layers.

5. The method of simultaneously applying thin coatings of a plurality of gelatin and polyvinyl alcohol solutions onto a web support in distinct layer relationship comprising the steps of forming a coating bed of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers and moves away from the bead with the solutions in distinct superposed layers.

6. The method of simultaneously applying thin coatings of a plurality of liquid gelatino silver halide emulsions onto a web support in distinct layer relationship comprising the steps of forming a coating bed of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers and moves away from the bead with the solutions in distinct superposed layers.

7. The method of simultaneously applying a gelatin solution and a liquid gelatino silver halide emulsion onto a web support in distinct layer relationship comprising the steps of forming a coating bed of said solution and emulsion in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said gelatin solution and said emulsion in the form of a layer into said bed and in superposed relation with each other whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers.

8. The method of simultaneously applying thin coatings of a plurality of polyvinyl alcohol silver halide solutions onto a web support in distinct layer relationship comprising the steps of forming a coating bed of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers in said bed and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers.

9. The method of simultaneously applying thin coatings of a plurality of polyvinyl alcohol silver halide emulsions onto a web in distinct layer relationship comprising the steps of forming a coating bed of said liquid gelatino and polyvinyl alcohol silver halide emulsions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said liquid gelatino and polyvinyl alcohol silver halide emulsions in the form of a layer into said bed and in superposed relation with each other whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers and moves away from the bead with the solutions in distinct superposed layers.

10. The method of simultaneously applying thin coatings of a plurality of gelatin and polyvinyl alcohol solutions onto a web support in distinct layer relationship comprising the steps of forming a coating bed of said material materials onto a web support in distinct layer relationship comprising the steps of making a solution of each of said colloidal materials, forming a coating bed of said solutions in bridging relation between the surface of the support and a coating device which is stationary relative to said bed and spaced transversely from said support, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation with each other whereby the individual layers are maintained in distinct superposed relation, and producing a continuous relative movement between the bead and the surface of said support whereby the support moves across and in contact with said bed and one surface of the support engages one of the outermost of the superposed layers in said bed and simultaneously picks up all of said layers and moves away from said bed with the solutions in distinct superposed layers.

11. The method of simultaneously applying thin coatings of a plurality of gelatin and polyvinyl alcohol solutions onto a web support in distinct layer relationship comprising the steps of making a solution of each of said colloidal materials, forming a coating bed of said solutions in bridging relation between the surface of the support and a coating device which is stationary relative to said bed and spaced transversely from said support, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation with each other whereby the individual layers are maintained in distinct superposed relation, and producing a continuous relative movement between the bead and the surface of said support whereby the support moves across and in contact with said bed and one surface of the support engages one of the outermost of the superposed layers in said bed and simultaneously picks up all of said layers and moves away from said bed with the solutions in distinct superposed layers.

12. The method of simultaneously applying thin coatings of a plurality of gelatin and polyvinyl alcohol solutions onto a web support in distinct layer relationship comprising the steps of making a solution of each of said colloidal materials, forming a coating bed of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bed and in superposed relation with each other whereby the individual layers are maintained in distinct superposed relation, and continuously moving the surface of said support across and in contact with said bed so that the surface of the support engages one of the outermost of the superposed layers in said bed and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers.
support across and in contact with said bead so that the surface of the support engages one of the outermost of the superposed layers in said bead and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers, and setting the deposited layers of said solutions to prevent them from flowing relative to each other and said support.

13. The method of simultaneously applying thin coatings of a plurality of aqueous gelatin solutions onto the surface of a flexible web support in distinct layer relationship comprising the steps forming a coating bead of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bead and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation, continuously moving the surface of said support across and in contact with said bead so that the surface of the support engages one of the outermost of the superposed layers in said bead and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers whose individual relative thicknesses depend upon the rate at which each solution is fed into the bead and whose combined thickness depends upon the speed of the support, and simultaneously drying said deposited layers of solution.

14. The method of simultaneously applying thin coatings of a plurality of polyvinyl alcohol solutions onto the surface of a flexible web support in distinct layer relationship comprising the steps forming a coating bead of said solutions in bridging relation between the surface of the support and a stationary coating device spaced transversely therefrom, simultaneously feeding each of said solutions in the form of a layer into said bead and in superposed relation to the other solutions whereby the individual layers are maintained in distinct superposed relation, continuously moving the surface of said support across and in contact with said bead so that the surface of the support engages one of the outermost of the superposed layers in said bead and simultaneously picks up all of said layers and moves away from the bead with the solutions in distinct superposed layers whose individual relative thicknesses depend upon the rate at which each solution is fed into the bead and whose combined thickness depends upon the speed of the support, and simultaneously drying said deposited layers of solution.

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