

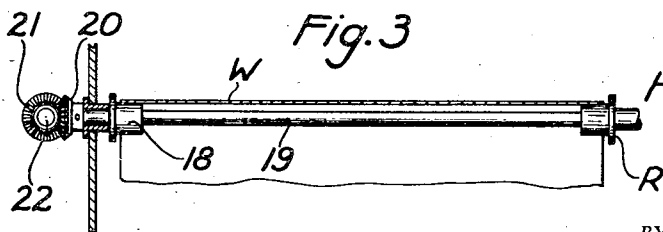
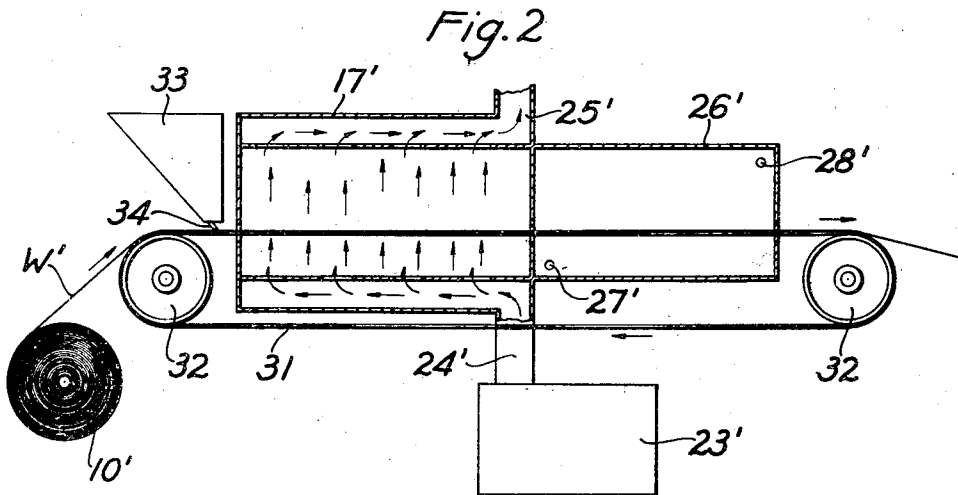
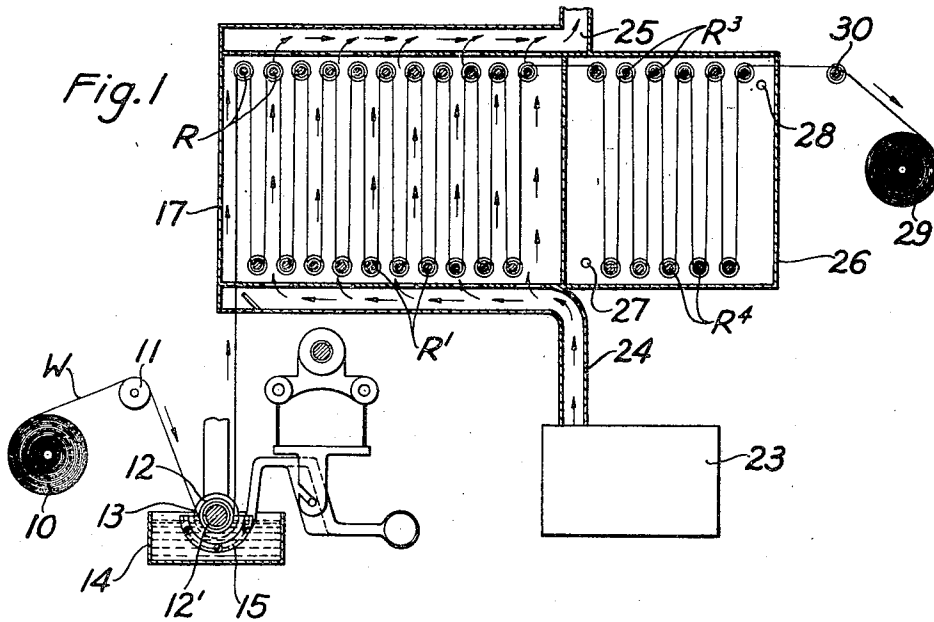
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H. E. VAN DERHOEF ET AL.

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PROCESS FOR COATING SUPPORTS

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Henry E. VanDerhoef
Alfred E. Brooks
INVENTORS

BY *Newton M. Perkins*
Harold J. Thompson
ATTORNEYS

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PROCESS FOR COATING SUPPORTS

Henry E. Van Derhoef and Alfred E. Brooks,
Rochester, N. Y., assignors to Eastman Kodak
Company, Rochester, N. Y., a corporation of
New Jersey

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11 Claims. (Cl. 91-69)

This invention relates to a process for drying and setting photographic emulsions or similar coatings applied to a continuous support.

The manufacture of sensitive film includes the steps of applying a coating of warm and liquid sensitive emulsion to the film support, setting the emulsion, and then completely drying the same. The setting process involves the cooling of the warm and liquid emulsion layer to a temperature below the setting point thereof. This process is commonly accelerated by passing the support, after coating, into a chilling chamber suitably cooled by ice, mechanical, or other refrigerating means, whereby the emulsion is chilled to its setting point almost instantly. Usually this is accomplished by the transfer of heat from the emulsion to the air as sensible heat, since the air is cooled below its dew point and is therefore substantially saturated. After the emulsion has been set, the support is fed through one or more drying chambers kept at a suitable temperature by a current of warm dry air passing therethrough it. These drying chambers must be relied upon to completely dry the emulsion, because due to the air in the chilling chamber being saturated no drying action can take place therein. Other setting processes are known where the emulsion is set by transferring the heat directly to a chilled drum over which the film is fed after being coated.

It will be obvious that when the emulsion is set almost instantly, as by chilling, there is no chance for the same to flow and even itself to give a smooth and even coating. On the contrary, the evenness of the coating depends entirely upon the adjustment and efficiency of the means employed for applying the emulsion to the support. Further, when the emulsion is chilled to set the same there can be no drying action accomplished during this setting step due to the fact that the air in being chilled is brought to a temperature below its dew point at which temperature the air is saturated and cannot take up any moisture.

Therefore, one object of the present invention is the provision of a process for setting and drying a coating having the characteristics of a sensitive emulsion which permits a gradual setting of the coating whereby the coating can tend to flow and even itself prior to setting.

Another object of the invention is to provide a method utilizing a coating station and a setting and drying chamber with means for feeding the support through the two so that the support will be maintained in such a position that the

liquid emulsion will tend to even itself prior to setting, but will not flow off the edges of the support or form flow ridges.

A further object of the invention is the provision of a process for setting and drying a coating of the type described wherein drying and setting of the coating is effected simultaneously.

And still another object is to provide a process for the purpose described by which warm air is used in the setting chamber instead of chilled air.

Another object is to provide a process for the purpose described by which the air in the setting and drying chamber is conditioned to have a wet bulb temperature below the setting point of the coating, whereby the transfer of heat from the coating to the air is believed to be due largely to heat transfer accompanying evaporation.

Briefly, the present invention relates to a process for drying and setting a coating on a support, which coating has the characteristics of a sensitive emulsion, or comprises an aqueous solution including a colloidizing material, wherein the coating is set gradually by warm air so conditioned that setting and drying of the coating occurs simultaneously due to evaporation and the transfer of heat accompanying evaporation; the coated support being so handled as to allow the coating to even itself during the gradual setting thereof.

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

Fig. 1 is a diagrammatic section showing one form of apparatus for coating a continuous support, and setting and drying said coating, with which our novel setting and drying process can be beneficially practiced.

Fig. 2 shows another form of apparatus with which our novel setting and drying process can be beneficially practiced.

Fig. 3 is an enlarged detail of one of the upper rollers in the setting chamber of Fig. 1, and showing the manner in which they are driven to move the support through the chamber.

Like reference characters refer to corresponding parts throughout the drawing.

In present apparatus and processes for coating supports with coating solutions having setting

characteristics, the coating is applied to the support by the immersion method or by the coating being flowed onto the support from a suitable hopper; and the coating after being smoothed out by doctor blades, or the like, is instantly chilled to set the coating to prevent it from flowing off the support as it is passed onto the drying chamber to be dried. This instant setting of the coating has been considered imperative to insure an even layer of the coating effected by doctor blades, or other mechanical means, because no apparatus or method was considered suitable for moving the support through the coating, setting, and drying steps in such a manner that the coating material would not flow off of the support or tend to form undesirable ridges or flow marks.

We have found that if the setting of the coating is effected gradually instead of instantly the coating will tend to smooth itself out, the irregularities of the coating layer tending to disappear, and give a coating layer which is consistently more uniform than any coating which can be controlled by doctor blades, or the like. And we have also found that by moving the continuous support through the setting chamber at the same speed and in substantially the same plane as when coated a gradual setting of the coating, wherewith the coating tends to smooth itself, can be accomplished without the coating tending to run off of the support or form flow ridges, difficulties heretofore encountered in coating methods when attempting a gradual setting of a coating solution. Throughout this specification when we refer to the support being moved through the setting chamber in substantially the same plane as when coated, we refer to planes which are substantially parallel, e. g. vertical or horizontal, as distinguished from planes which are considerably out of parallel; and not necessarily, geometrically speaking, to a single plane.

In the drawing two forms of apparatus are shown whereby the process may be beneficially practiced. The drawing, however, shows the essential features of the machine only, not the details of construction.

Referring now to Fig. 1, the film, paper, or continuous support W to be coated is led from the supply roll 10 over the guide roll 11 and thence under an immersion roll 13 where the support is immersed in the liquid coating solution contained in the hopper 14. The coating solution can be an aqueous solution including any material having setting characteristics, such as a sensitive photographic emulsion, and such solutions may be broadly classified as aqueous solutions including a colloidizing material. Although it is not imperative to the invention, for the purpose of illustration I have chosen to show this coating apparatus as being of the type shown in pending application, Serial Number 184,456, filed January 11, 1938, in the names of David A. Babcock and Henry E. Van Derhoef to which application reference can be had for a more detailed description of the same. Essentially, this immersion roll 13 comprises a pair of spaced edge supporting rollers 12 on which the support is supported at its edges only, the hub 12' between the rollers being reduced in diameter so as not to contact the surface of the support at any time. Counter-balanced safe edge cups 15 encase the ends of the edge supporting rollers 12 and prevent the coating solution from coming in contact with that portion of the support W supported by the edge rollers, so that the edges

of the support will be maintained dry for the purpose hereinafter described.

From the immersion roll 13 the support W moves vertically and into the setting and drying chamber, indicated generally at 17. In this chamber the support is supported in vertical loops by being passed over staggered upper rollers R and lower rollers R¹, and it should be noticed that the upper and lower rollers are so positioned relative to one another that the support in passing from one to the other moves in a vertical plane the same as does that portion of the support passing from the coating apparatus to the setting and drying chamber. While the ideal support advancing condition is accomplished when the plane of the support in moving through the setting and drying chamber is maintained absolutely parallel to the plane through which it passes when coating is applied thereto, it has been found that satisfactory results can be obtained if the plane of the film in moving through the drying and setting chamber is within 15° of being parallel with the plane thereof when coating is applied. This allowable discrepancy of planes through which the support may pass permits more ready assembly of the rollers R and R¹ in that their relative positions need not be rigidly controlled to insure the support passing between any two being in a plane exactly parallel to that through which the support passes when coating is applied thereto. The rollers R and R¹ may be of the form shown in Fig. 3 including flanged edge rollers 18 connected by a reduced spindle 19 whereby the support is supported only at its edges which remain uncoated due to the particular form of immersion roll 13 described above. As pointed out on the above-noted pending application it has been found that the cylindrical supporting portions of the flanged edge rollers 18 need only be 2¼ inches in diameter in order to support a web .005 inch and 54 inches wide. Any suitable means may be provided for advancing the support from the supply roll 10 through the coating apparatus and through the drying and setting chamber 17, but it is imperative that the linear speed of any portion of the support in moving through the drying and setting chamber be equal to the speed at which that same portion of the support was moved when the coating was applied thereto. As one way of accomplishing this support movement, each of the upper rollers R may include a bevel gear 20 fixed to the end of the spindle 19 projecting outside the chamber 17, see Fig. 3. Each bevel gear 20 engages a corresponding bevel gear 21 fixed to the drive shaft 22 extending longitudinally of the chamber 17 in substantially the same plane as of the rollers R, and this drive shaft may be driven by any suitable source of power, such as a motor, not shown. Since rollers R engage the uncoated edges of the support W there will be sufficient friction between the support and rollers to advance the support through the apparatus. If necessary, the support engaging portions of the rollers R may be rubber or other suitable material to give a friction drive for the support which would be free of slippage.

We have found that if the web is moved in substantially the same plane, in this instance vertical, and at the same speed through the drying and setting chamber 17 as when coated, that the setting of the coating can be accomplished gradually and the coating will tend to smooth itself without running off the edges of the support or forming flow ridges. This is accom-

plished by the described support feeding means disclosed, because the same feeding means moves the film through the coating apparatus and the drying and setting chamber, and the diameter of the rollers R is so small, $2\frac{1}{4}$ inches, that the short time that any portion of the support passing thereover is not in the vertical plane can be neglected since it does not effect the flow of the coating due to the change in the plane of movement thereof. It is pointed out that during the instant any portion of the support W is immersed in the coating solution no application of a definite layer of coating is being applied to the support, but that the actual application of the layer of coating material takes place as the support leaves the coating solution, which in this instance is during the movement upward in a vertical plane. Therefore, throughout this specification when we refer to the plane of movement of the support when coated, we are referring to that instant when the desired layer of coating is applied to the support, and not to the complete time of immersion of the support in the coating solution. Although we are not sure why, we have found that if the speed of the support is kept equal throughout the apparatus and free from acceleration or de-acceleration, the coating layer will not tend to flow an appreciable amount due to gravity. It may be explained that the coating layer upon leaving the hopper will have a moment of inertia in the direction of movement of the support which is sufficient to overcome the effect of gravity for a sufficient time until the support changes in direction. However, any slight movement of the coating layer in one direction longitudinally of the support due to gravity will be overcome by an equal and opposite movement when the support changes direction, so that by the time the support has left the setting chamber, completely set, these flow tendencies have equalized themselves and are not noticeable. It might be pointed out that the flow tendencies of the coating on any portion of a support decrease by increasing amounts as that portion of the support moves from the coating station and through the drying and setting chamber, due of course to the increase in viscosity of the coating as it is cooled and dried, so that any flow tendencies of the coating gradually decrease until the coating becomes set.

The layer of coating on the support is set while passing through the setting chamber by conditioned air issuing from any suitable air-conditioning outfit 23 through inlet duct 24 into the chamber 17 and out the exhaust duct 25, as indicated by the arrows. The air circulated through the setting and drying chamber 17 is so conditioned that it will be warm in comparison to the setting temperature of the coating solution, but will have a wet-bulb temperature below the setting point of the coating. Air with this difference in wet and dry bulb temperature will be fairly dry and will be capable of readily absorbing considerable water vapor. The air having a relatively high dry bulb temperature will aid evaporation, and the heat accompanying the evaporation will have to come from the coating solution. The temperature to which the coating will drop due to evaporation, will be determined by the wet bulb temperature of the air, so if the wet bulb temperature of the air is below the setting point of the coating material said material will be lowered in temperature to or below the setting point and will become set. In order to insure sufficient evaporation of the water from

the coating solution, which, as explained, must be an aqueous solution in order that the setting point could be figured in terms of wet bulb temperature of an ordinary thermometer using water to wet the bulb, a sufficient air circulation is required to carry off the air as it picks up moisture to continually present new air which is fairly free of moisture. Such a circulation of air may be accomplished by a blower and an exhaust fan, not shown, suitably situated in the inlet and outlet ducts 24 and 25 respectively. A specific example of satisfactory air conditions in the setting and drying chamber for carrying out our setting and drying process is as follows: Assuming we are coating with a suitable sensitive emulsion the setting temperature of which is 80° F., the setting temperature of such emulsions may vary from 75° to 90° F. depending upon the amount of gelatin used therein, we have found that a gradual setting and drying of the emulsion coating will be accomplished if the air is conditioned so as to have a dry bulb temperature of 80° F., and a wet bulb temperature of 60° F., and an air velocity through the chamber of $600'$ per minute. Air having wet and dry bulb temperatures of 60° and 80° F. respectively, has a relative humidity of 30 per cent so that it is capable of taking up quite a bit of moisture. Further the dew point of this air is 45° F. which is well below the setting point of the emulsion.

Just what takes place during the evaporation of the water from the emulsion in the drying and setting chamber to cause the emulsion to cool down to the wet bulb temperature of the air irrespective of the dry bulb temperature we are not sure, but it might be answered by the discussion of vaporization in relation to the kinetic theory in the text entitled, "Chemical Principles," by Noyes and Sherrill. According to this text, when a liquid is placed in communication with an empty space, its molecules, which according to the kinetic theory are continually in motion, will escape from its surface into the space above it until the vapor attains such a pressure that the number of molecules entering the liquid surface from the vapor side becomes equal to the number of molecules leaving the surface from the liquid side. When this occurs a stationary condition of equilibrium is evidently established, and then prevailing pressure of the vapor represents the vapor pressure of the liquid.

In accordance with this theory it might be that the emulsion coating in the setting chamber acts as a liquid in communication with an empty space and the molecules of water pass up through the emulsion according to the kinetic theory and escape into the air. Since this air is conditioned so as to be quite unsaturated and is circulated at a suitable rate, the vapor pressure of the air will never attain such a pressure that the number of molecules entering the emulsion from the air will become equal to the number of molecules leaving the emulsion, but the air will continually have a strong affinity for moisture due to its controlled humidity. The fact that the emulsion is cooled during evaporation may be due to the fact that heat from the emulsion is converted into kinetic energy for moving the molecules of water through the emulsion and out into the air, in consequence of which the emulsion is cooled down to the wet bulb temperature of the air which is below the setting temperature of the coating material.

Regardless of whether or not the evaporation of the water from the emulsion and the cooling

of the emulsion takes place in accordance with the theory discussed, we know that the desired results are obtained by the process outlined above. This process permits the use of warm air which cools the emulsion more slowly by evaporation as discussed above, and the support advancing means maintains the support in such a position throughout the setting chamber that the coating while liquid tends to even itself thus correcting for most of the irregularities in the coating and some of the irregularities in the surface of the support. The time required for setting, which can be varied by changing the dry bulb temperature of the air and the circulation thereof, is varied in accordance to the thickness of the layer applied and the degree of evenness desired. We have found that an interval of 30 seconds between coating and setting with the usual emulsion coating solutions is satisfactory, but this time may be increased to 90 seconds or even longer, if desired. The more regular the surface of the support, the longer the setting period that is desirable. This is true because when the surface of the support is quite irregular, the emulsion tends to fill the hollows and run from the ridges of the hollows. When flat supports are used, the emulsion need never set until the evaporation has removed all of the moisture, during which time all irregularities of the emulsion coating tend to disappear while the emulsion is liquid.

It will be obvious to those skilled in the art that with our process where the emulsion coating is cooled due to a transfer of heat accompanying evaporation, the coating is dried simultaneously with its being set. Thus two steps, which are entirely separate in the prior art where setting is accomplished by chilling, are combined into one to decrease the total drying time and make the complete apparatus more compact. Ordinarily, the time of setting is not sufficiently long to accomplish a complete drying of the emulsion, but the support after being set and partially dried is passed through a drying chamber 26 where the partially dried emulsion is completely dried. This drying chamber may have heated air circulated therethrough, coming in an inlet 27 and going out at outlet 28, for drying the emulsion, and the support may be fed therethrough over staggered rollers R3 and R4, similar in construction to rollers R and R1, rollers R3 being driven from the drive shaft 22 in the same manner and at the same speed as rollers R. When the support leaves the drying chamber 26 the emulsion is completely dried, and the support is wound up on a takeup roll 29 after passing over idler roll 30. If the support is sufficiently flat and the duration of the setting time is not limited, it is evident that the setting chamber 17 could be increased in length so that the coating on leaving this chamber would be completely dried as well as set. Such a procedure would necessarily result in a more compact machine since the chamber 26 ordinarily used for drying alone could be done away with.

In Fig. 2 we have shown an arrangement wherewith a support is coated while moving in a horizontal plane, the support being moved through the conditioned setting and drying chamber in the same plane and at the same speed as when coated. In this arrangement the setting and drying chamber 17' and the subsequent drying chamber 26' are the same as described in connection with the above arrangement. The support or web W' instead of moving through the chamber in a vertical plane is led

from the supply roll 10' onto an endless band 31 which passes through the chambers 17' and 26' in a horizontal plane. This endless band, 31, which should be rigid to form a solid and flat support for the web may be made of sheet metal or any other suitable material, and is mounted on and moved by driving rollers 32 both of which are driven at the same speed by any suitable driving means. The support W' to be coated is led from the supply roll 10' over the band 31 in the direction as indicated by the arrows, through the setting and drying chamber 17', through the drying chamber 26', and is then taken up by any suitable takeup roll, not shown. The takeup means is preferably driven at such a speed that the support will be moved at the same linear speed as that portion of the band 31 running in the horizontal plane, and such a drive will necessarily have to be a variable speed drive to account for the change in diameter of the takeup roll.

The coating solution is contained in a hopper 33 from which it is flowed onto the support through any suitable applying means 34. After being coated the support W' is moved into and through the drying and setting chamber 17' in the same plane and at the same speed as when coated to allow the coating to even itself while in the liquid position, as described in connection with the arrangement shown in Fig. 1. In this arrangement the setting and drying chamber 17' is the same and the air passing therethrough is conditioned the same as described in connection with the previously disclosed arrangement so that no further description thereof is necessary. The only difference there is between the form of the arrangement shown in Fig. 2 and that shown in Fig. 1 is in the coating apparatus and the manner of feeding the support W', after coating, through the drying and setting chamber at the same speed and in the same plane as when coated; and is disclosed to show that the invention is not limited to one particular form of apparatus.

Although we have described our apparatus and process particularly in connection with coating a sensitive emulsion on a continuous film support, it is to be understood that the same are applicable to the application of any coating having the characteristics of a sensitive emulsion. This classification of coating material includes an aqueous solution including a colloidizing material, and would include aqueous solutions of agar-agar, gelatin, dextrine, etc. Coatings of this last-mentioned group might be used as protective colloidal coatings on paper, film, or any number of different web materials. If the coatings are used merely for protective purposes or for placing a desirable finish on a support, it will be understood that the uniformity of the coating layer will not be so stringent as it would with the application of sensitive emulsion coatings. Therefore, in such cases it is perfectly possible to so condition the air in the setting and drying chamber that the coating will be completely dried without setting, in the sense that the term setting is usually used, or the setting and complete drying of the coating can be accomplished in any desired time relation.

Although we have shown and described certain specific embodiments of our invention, we are fully aware that many modifications thereof are possible. Our invention, therefore, is not to be restricted except insofar as is necessitated

by the prior art and by the spirit of the appended claims.

Having thus described our invention what we claim is new and desire to secure by Letters Patent of the United States is:

1. The process of coating a support with an aqueous solution of a colloidal material capable of gelling at a given temperature which comprises, coating the support with the solution, then passing the support through an unsaturated atmosphere the dry bulb temperature of which is above the gelling temperature of the colloidal material and the wet bulb temperature of which is below the gelling temperature of said material, and moving said support through said atmosphere at the same speed and in a plane substantially parallel to the plane of the support as when coated until the coating has been sufficiently dried.
2. The process of coating a support with an aqueous solution of a hydrophilic colloidal material capable of gelling at a given temperature which comprises, coating the support with the solution, then passing the support through a conditioned atmosphere which is at a higher dry bulb temperature than the gelling temperature of said material and unsaturated, and the wet bulb temperature of which is below the coating temperature of the solution.
3. The process of coating a support with an aqueous solution of a colloidal material capable of gelling at a given temperature comprising, coating the support with the solution, then passing the support through a conditioned atmosphere which is at a higher dry bulb temperature than said gelling temperature and unsaturated, and the wet bulb temperature of which is below the gelling point of said colloidal material.
4. The process of coating a support with an aqueous solution of a colloidal material capable of gelling at a given temperature comprising the steps of, coating the support with the solution, then passing the support through a conditioned atmosphere which is at a higher dry bulb temperature than said gelling temperature and unsaturated, and the wet bulb temperature of which is below said gelling point to simultaneously gel and partially dry the colloidal material, and finally passing the support through a warm unsaturated atmosphere where drying of the colloidal material is completed.
5. The process of coating a support with an aqueous solution of a colloidal material capable of gelling at a given temperature comprising the steps of, coating the support with the solution, passing the support through an atmosphere conditioned so as to be unsaturated and at a higher dry bulb temperature than the gelling temperature of said colloidal material, and having a wet bulb temperature below said gelling temperature, whereby the colloidal material is simultaneously gelled and dried, and moving said support through said atmosphere in substantially the same plane and at the same speed as when coated until the colloidal material has gelled.
6. The process of coating a support with an aqueous solution of a colloidal material capable of gelling at a given temperature comprising the steps of, coating the support with the solution, moving the coated support through a chamber in substantially the same plane and at the same speed as when coated, circulating air through said chamber, which air is conditioned so as to be at a higher dry bulb temperature than said gelling temperature and unsaturated, and have a wet bulb temperature below the gelling temperature of said colloidal material, and circulating said air through said chamber at a sufficient rate to evaporate the water from the solution at a rate that will cool the colloidal material to the wet bulb temperature of the conditioned air.
7. The process of coating a support with an aqueous solution of a colloidal material capable of gelling at a given temperature comprising the steps of, coating the support with the solution, moving the coated support through a chamber in substantially the same plane and at the same speed as when coated, circulating air through said chamber, which air is conditioned so as to be at a higher dry bulb temperature than said gelling temperature and unsaturated, and have a wet bulb temperature below the gelling temperature of the colloidal material, circulating said air through said chamber at a sufficient rate to evaporate the water from the solution at a rate that will cool the colloidal material to said wet bulb temperature, and passing the coated support through a drying atmosphere until the colloidal material is completely dry.
8. The process of coating a support with a light sensitive emulsion having a given gelling temperature, comprising the steps of, coating the support with the emulsion, moving the coated support through a chamber in substantially the same plane and at the same speed as when coated, circulating air through said chamber, which air has been conditioned so as to have a dry bulb temperature approximately the same as the coating temperature of the emulsion and a wet bulb temperature below the gelling point of the emulsion, whereby the emulsion is gelled and partially dried, and passing said coated support through a subsequent drying atmosphere until the emulsion is thoroughly dried.
9. The process of coating a support with a light sensitive emulsion having a gelling temperature between 60° F. and 80° F. comprising the steps of, coating the support with the emulsion, passing the coated support through a circulating conditioned atmosphere the dry bulb temperature of which is 80° F. and the wet bulb temperature of which is 60° F. until the emulsion is gelled, and then passing said support through a drying atmosphere until it is completely dried.
10. The process of coating a support with an emulsion having a gelling temperature between 60° F. and 80° F. comprising the steps of, coating the support with the emulsion, passing the coated support through a circulating conditioned atmosphere the dry bulb temperature of which is 80° F. and the wet bulb temperature of which is 60° F. until the emulsion is gelled and completely dried.
11. The method of simultaneously drying and gelling a light sensitive emulsion having a given gelling temperature on a film strip comprising passing the freshly coated strip through a circulating atmosphere so conditioned as to be unsaturated, have a dry bulb temperature above said gelling temperature, and have a wet bulb temperature below said gelling temperature, whereby the coating is partially dried and gelled due to evaporation and the heat transfer accompanying evaporation.

HENRY E. VAN DERHOEF.
ALFRED E. BROOKS.