Sept. 5, 1961 W. W. ROWE 2,998,841

PROCESS AND APPARATUS FOR TREATING WEBS WITH RESIDUAL FILMS

Filed Feb. 16, 1954 2 Sheets-Sheet 1

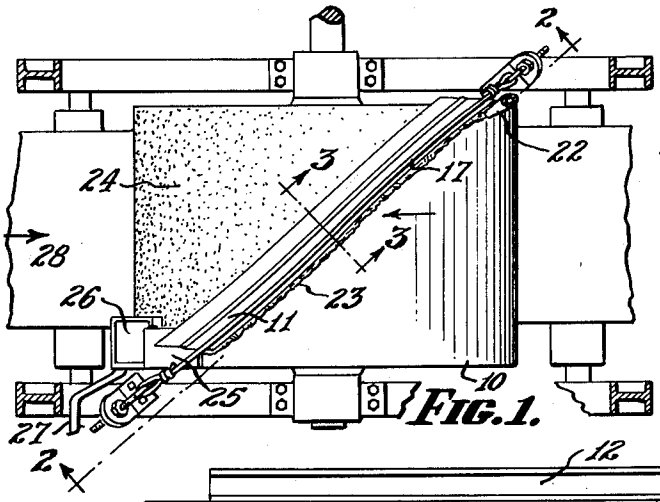


FIG. 1.

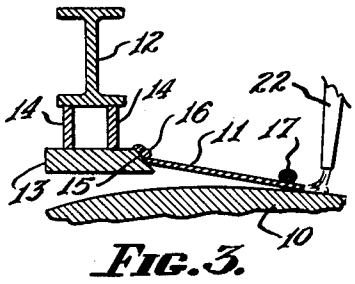


FIG. 3.

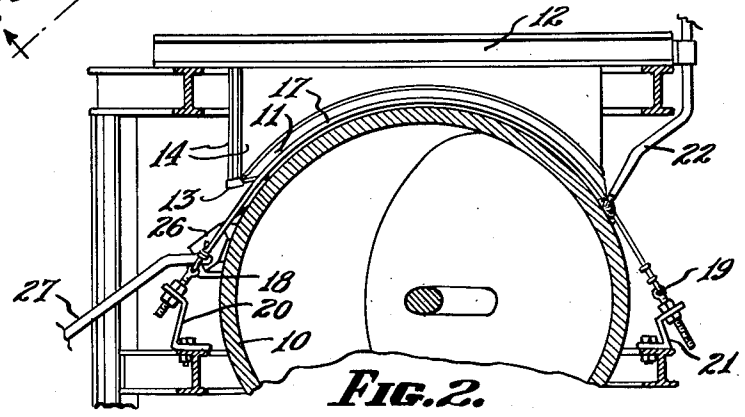


FIG. 2.

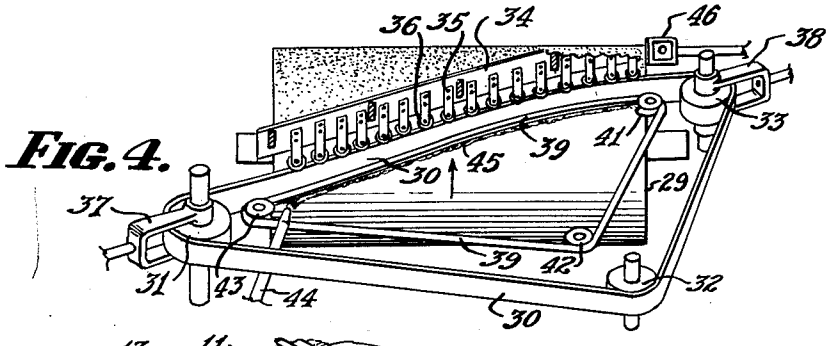


FIG. 4.

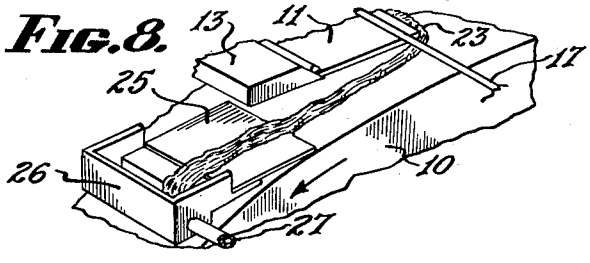


FIG. 8.

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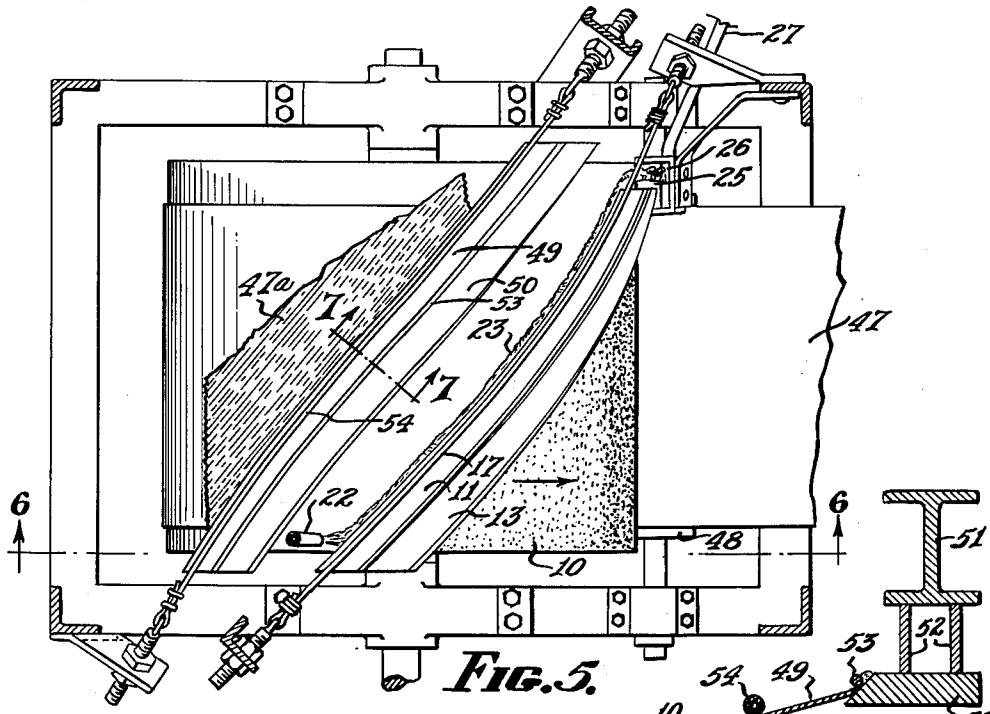


FIG. 5.

FIG. 7.

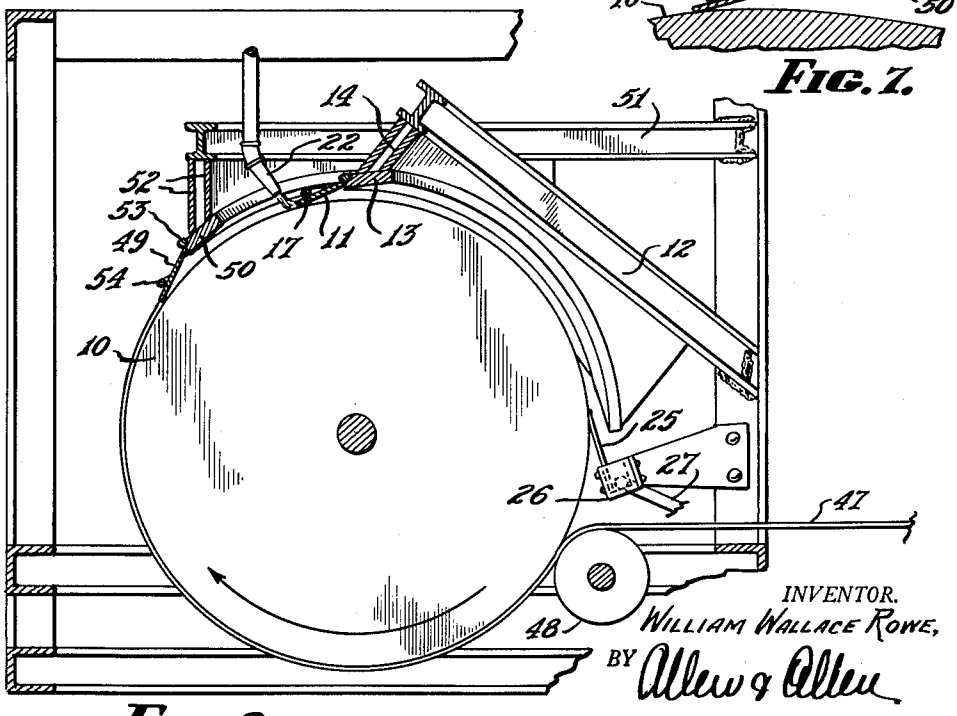


FIG. 6.

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United States Patent Office

2,998,841
Patented Sept. 5, 1961

2,998,841

PROCESS AND APPARATUS FOR TREATING WEBS WITH RESIDUAL FILMS

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Filed Feb. 16, 1954, Ser. No. 410,480
18 Claims. (Cl. 154—30)

The application of coating substances to paper, cloth or other flexible webs has been practiced in many ways, as by spraying, doctoring, imprinting, roller coating and the like. The present invention relates to an apparatus and procedures in which a film of the coating substance is first formed on a moving surface, to which a flexible web may then be led so as to come into contact with the residual film.

It is an object of the invention to provide means and a method whereby residual films of coating substance may be formed on a moving surface with more perfect control as to thickness and uniformity.

It is an object of the invention to provide means and a method for forming residual films, wherein a wide variety of coating surfaces, differing as to consistency and characteristics, may be handled.

It is an object of the invention to provide apparatus and a method wherein the quantity of coating substance being manipulated for the formation of a residual film can be controlled and kept constant both in toto and at all points transverse the surface on which the residual film is being formed. This permits accurate control of the nature of the formed film in spite of changes such as polymerization, drying and the like, which may be progressively occurring in the coating substance.

It is an object of the invention to provide an apparatus and method wherein a formed residual coating on a moving surface may be uniformly tempered or otherwise treated prior to being brought into contact with the flexible web, or otherwise removed from the moving surface. This permits the formation of the film under one set of circumstances and its application to the web under a controllably different set of circumstances.

It is an object of the invention to provide apparatus and a method wherein the formation of a residual film, and if desired, a treatment thereof after formation, can be accurately correlated with subsequent treatments of the web so as to coact therewith in a new way.

These and other objects of the invention, which will be set forth hereinafter, or will be apparent to one skilled in the art upon reading these specifications, are accomplished by that procedure and through the use of apparatus of which certain exemplary embodiments will now be described.

Reference will be made to the accompanying drawings wherein:

FIG. 1 is a partial plan view of an apparatus for forming residual coatings.

FIG. 2 is a diagonal sectional view thereof taken along the line 2—2 of FIG. 1.

FIG. 3 is a partial transverse section taken along the line 3—3 of FIG. 1.

FIG. 4 is a partial plan view of another form of apparatus for the production of residual film.

FIG. 5 is a partial plan view of an apparatus embodying both means for forming a residual film and creping means.

FIG. 6 is a sectional view taken along the line 6—6 of FIG. 5.

FIG. 7 is a partial sectional view taken along the line 7—7 of FIG. 5.

FIG. 8 is a partial perspective view of apparatus at the exit end of the film forming means.

In the exemplary embodiments herein described, the moving surface referred to takes the form of a driven roll or cylinder. Other moving surfaces may be employed such, for example, as the surface of a traveling metallic belt. Residual films have hitherto been formed on the surfaces of cylinders through the use of stationary or roll doctor means, the coating substances being caught in the bite between the cylinder and the doctor, the doctor acting to spread it on the surface of the cylinder. With many kinds of coating substances, this presents serious problems. The amount of coating substance caught in the bite will vary transversely of the moving surface being coated, so that if any progressive changes occur in it, the nature of the residual film will vary transversely of the moving surface. Furthermore, irregularities in the contacting portions of the cylinder and doctor produce transverse variations in the thickness of the residual film.

An important basis of the present invention lies in the utilization of the fact that if the coaction of the moving surface on which the film is being formed and the doctor can be arranged to exert on the coating substance a force transverse the direction of movement of the moving surface, the coating substance can be caused in the bite to travel progressively along the bite from one end to the other. When this is accomplished, if the coating substance is fed at a continuous rate to what will be termed the "entrance" end of the bite, it will travel continuously toward the exit end of the bite in controlled amounts. This means not only that there will always be a sufficient quantity of the coating substance in all portions of the bite, but also that no increment of the coating substance will be engaged in the actual manipulation in the bite for a longer time than it takes any such increment to travel from one end of the bite to the other. Thus, a condition permitting some portions of the coating substance to remain in the bite undergoing progressive changes for longer times than other increments is completely avoided. Substances which undergo progressive polymerization, or which are susceptible to changes in viscosity or other qualities due to the evaporation of a solvent, the breaking of an emulsion or the like, may be used under completely controlled conditions in the practice of this invention.

It is possible to feed the coating substance to the entrance end of the bite in such quantity continuously that it will be used up in forming the residual film by the time any portion of it reaches the opposite end of the bite. It is equally possible and usually preferable to feed the coating material to the entrance end of the bite in excess so that some of it flows off at the other end of the bite, which is now conveniently referred to as the "exit" end. In either event the length of time any increment of the coating material is engaged in the bite can be exactly controlled. It does not violate the principles of the invention to feed the coating material into the bite by suitable means across its extent; but this is not ordinarily necessary.

The arrangement of the doctor and the moving surface so that a force is exerted on the coating substance transverse the direction of motion of the moving surface can be accomplished in two ways. First, the doctor can be approached to the moving surface along a line forming an angle with a line normal to the direction of movement of the surface. The greater this angle becomes, the larger will be the transverse force acting on the coating material. While the angularity may be considerably varied beyond these limits, doctor elements which lie at angles varying, say, from 35° to 55° to the direction of of motion of the moving surface will be found entirely satisfactory and will produce a satisfatcory travel of the coating substance along the bite.

A second way in which the travel of the coating material along the bite may be enforced is by producing relative two-directional movement of the traveling surface and the doctor. Thus, a doctor, which itself moves continuously in a direction transverse the direction of movement of the moving surface, will cause travel of the coating surface along the bite even though it contacts the moving surface along a line normal to the direction of movement of the surface. Combinations may be effected in which a moving doctor also is arranged at an angle other than 90° to the direction of movement of the moving surface.

To illustrate an embodiment of the first type of apparatus assembly, reference is made to FIGS. 1, 2 and 3. In this embodiment the moving surface is a cylinder **10** mounted in a frame on suitable bearings and arranged to be driven by means not shown. The doctor in this case is a relatively thin and flexible strip of metal **11** which conforms to the surface of the cylinder along a substantially helical line at its front or leading edge. A beam **12** extending diagonally of the machine frame carries a support **13** for the rear edge of the doctor. This support is curved and generally follows the helical line of the doctor, but is held away from the surface of the cylinder **10** by members **14** extending downwardly from the beam. The doctor support **13** has a slanting contacting edge **15** provided with a continuous or other abutment means **16** for the other edge of the doctor which is disposed as shown in FIG. 3. The doctor is thus somewhat tilted with respect to the surface of the cylinder **10** so that only the edge hereinabove referred to as the contacting edge, contacts the surface of the cylinder. A strand-like element **17**, which may be in the nature of a wire rope or cable, overlies the doctor near its front edge. The strand **17** is strongly tensioned so as to hold the leading edge of the doctor down into contact with the surface of the cylinder **10**. While other arrangements may be employed, the ends of the strand **17** have been shown connected to I-bolts **18** and **19** which engage in ears or brackets **20** and **21** on the machine frame. The I-bolts are equipped with nuts whereby any desired tension may be exerted on the strand **17**.

Since the doctor **11** is relatively flexible, and since it is disposed in a generally helical position with respect to the surface of the cylinder **10**, the action of the strand **17** will be to hold the contacting edge of the doctor down into close contact with the surface of the cylinder despite transverse irregularities in the cylinder surface. In this way the pressure of the doctor against the cylinder can be made very uniform. The contacting edge of the doctor forms an angle or V with the surface of the cylinder, and this also has an effect in controlling the thickness of the coating. The smaller the angle of the V, the greater will be the tendency for a coating material of given viscosity to be forced between the knife and the cylinder surface under any given power applied to the cylinder to rotate it. By controlling the V, the pressure of the contacting edge of the doctor against the cylinder surface, the viscosity of the coating substance and the power applied to the cylinder, a very accurate control of the weight or thickness of the residual film may be exercised.

In practice, the contacting edge of the doctor is usually the leading edge and has been so shown in the drawings. This is not necessarily so, however, and the invention may be practiced with the contacting edge of the knife forming the trailing edge (as respects the direction of rotation of the cylinder), in which case the V will be the angle or bite formed between the side edge of the knife and the surface of the cylinder.

The coating substance is indicated as fed to the entrance end of the bite through a suitable conduit or spout **22**. The cylinder is shown as turning in the direction of the arrow marked thereon in FIG. 1. The coating substance forms a tumbling or working mass **23** in the bite between the doctor **11** and the surface of the cylinder **10**; but by reason of the diagonal disposition of the doctor, the coating substance travels progressively along the bite. When the quantity of the coating substance fed is sufficient, that portion of it which is not used up in forming the residual film indicated in FIG. 1 at **24**, will leave the apparatus at the exit end of the bite. If the doctor extends entirely across the face of the cylinder **10**, the excess may be caught at the end of the cylinder. As most clearly shown in FIG. 8, however, it is preferable to terminate the doctor **11** short of the far end of the cylinder **10**, or to interrupt its contact with the cylinder near the far end of the bite. Any excess of the mass of coating substance **23** will then travel on the surface of the cylinder until it reaches a scraper **25** having a leading edge contacting the cylinder surface along a line parallel to the cylinder axis. The scraper **25** transfers the excess to a pan **26** from which it may be conducted away by a conduit **27**.

The doctor may be heated, if desired, by means not shown.

The progressive and continuous travel of the coating substance across the surface of the cylinder occurs under the combined actions of the moving cylinder surface and the diagonally arranged V of the doctor and is not greatly dependent upon the viscosity of the coating material. As a consequence, a very wide variety of coating materials may be employed, extending from thin liquids through highly viscous, flowable substances to pasty or plastic masses having very little, if any, flow characteristics under the action of gravity. As coating substances, there may be employed solutions of animal or vegetable adhesives or coating substances, cellulosic or other plastic materials, resins or the like, the solvents being any of those materials inclusive of water and volatile or nonvolatile organic liquids which are appropriate to the particular coating materials. Bitumens, waxes, resins and similar substances may be employed otherwise than in solutions, being softened, if desired, by the application of heat. Emulsions, dispersions or latices of bituminous, resinous, or rubbery substances in water or other liquids can likewise be employed in the practice of the invention. Materials having the characteristics of paints, lacquers and the like are also available. In fact, the apparatus and method may be employed with any coating substance capable of assuming a continuous liquid or plastic form so as to be workable and spreadable in the bite between the doctor and the moving surface of the cylinder and capable of being caused to travel along the bite as aforesaid.

When the residual film **24** has been formed on the moving surface as hereinabove described, a flexible web **28** may be brought against it. Normally it will be pressed against the surface of the residual film by a suitable pressure roll (not shown). In some types of coating operation the nature of the residual film may be such that the flexible web **28** may be merely brought against it under tension but without other pressure means, after which the flexible web will carry away the residual film when it is diverted from the surface of the cylinder. The formation of a residual film in the manner described, however, permits the film to be tempered or otherwise treated on

the surface of the cylinder prior to its application to the flexible web. This tempering or treatment may be brought about through a change in temperature, a controlled polymerization of a polymerizable substance, the controlled evaporation of a solvent, or the like. The cylinder **10** may be made hollow as shown and provided with means for the introduction and withdrawal of a heating or cooling fluid, or other heating or cooling means either as part of the cylinder **10** or as juxtaposed externally to the residual film after formation.

Thus, by way of one example, a residual film may be formed from a coating substance which, by reason of solvent softening or heat softening, is in a saturating condition at the time the film is formed; and the film may then be tempered by cooling, controlled drying or otherwise to a non-saturating consistency before the flexible web **28** is led against it. In this way a coating material may be applied to a web so as to form an external surface coating thereon, whereas under other circumstances the same coating material might be wholly or partially absorbed into the flexible web.

By way of another example, where the so-called coating substance is capable of being tempered or changed to a self-sustaining condition, as by temperature control or the elimination of a solvent, it is possible to peel or scrape the film from the surface of the cylinder without joining it to a flexible web, and thereafter to employ the film itself for various uses. Films of rubbery substance or cellulosic material are typical. Also, films formed as described may be so removed from the cylinder as to provide the coating substance in a flake or similar form.

In FIG. 4 there is shown diagrammatically another type of apparatus embodying a rotating cylinder **29**. In this instance the doctor **30** is a continuous metallic band having contact throughout a portion of its length with the cylinder surface but passing over sheave elements **31, 32** and **33**, at least one of which will driven so as to cause movement of the band-form doctor. A doctor support **34** is provided but the abutment means for the rear edge of the doctor now preferably takes the form of brackets **35** carrying small rollers or sheaves **36** to minimize friction. The doctor itself may be tensioned strongly by mounting two or more of the sheaves **31, 32** and **33** in bearings on movable yokes **37, 38** provided with tensioning means. However, it is also possible to depress the leading edge of the doctor **30** by means of a traveling strand **39** passing over sheaves **41, 42** and **43**. The strand will contact the doctor throughout that portion of it which lies against the surface of the cylinder; and by applying tensioning means to one or more of the last mentioned sheave elements, the action of the strand **39** can be made similar to that of the strand **17** hereinabove described. Although in the apparatus of FIG. 4 the requirements for angularity are not as great for a given desired speed of travel of the coating substance along the bite, the accurate conformation of the leading edge of the doctor to the surface of the cylinder is greatly facilitated by a helical arrangement such that the conformation of the doctor to the cylinder surface can be made continuous and uniform by tensioning. The coating substance may be again delivered by a spout or conduit **44**. It will travel along the bite in a tumbling mass **45**, as above explained, and may be removed off the edge of the cylinder by a pan and scraper **46**.

Apparatus such as that hereinabove described is particularly suitable for the application of residual films to flexible webs where the nature of the webs is such that they cannot be directly coated with highly viscous materials. This may occur either where the web is weak in and of itself, or where the direct application of a viscous coating substance would tend to remove desirable stretchability characteristics as, for example, where the web has been creped. All mechanical action involved in the formation of the residual film is exerted not against the flexible web but against mechanical instrumentalities which may be made strong enough to withstand the mechanical action involved and which may be driven under forces of sufficient magnitude. Even a weak or highly stretchable web may be led against the residual film after formation without the exercise of disruptive or other disadvantageous forces. After the web has been associated with the film, release from the moving surface may be accomplished in various ways. The film may be temporarily softened, as by the application of heat, to permit ready release of the web. The web and the coating may be scraped from the surface of the cylinder by suitable means. The web and the coating may also be removed from the surface of the cylinder by means acting to crepe the web. In the formation of double diagonally creped papers in accordance generally with the teachings of the Kemp Patents No. 2,008,181, No. 2,008,182 and No. 2,071,347, it will frequently be found desirable, after having produced a sheet of single diagonal crepes in the material, to bind the material to the second creping cylinder by means of a fresh application of adhesive. To apply this adhesive to the web is not usually practicable because of the danger of destroying a portion of its resident stretchability. Moreover, especially when creping with very thin applications of creping adhesive, it is desirable to keep the application as a wholly external layer either on the untreated web before any creping or on the single creped web before recreping it. Wholly external applications of coating substance are frequently desired also with cloth, unwoven cloth, and other types of reticulated webs. In all of these applications the present invention is of great utility.

FIGS. 5, 6 and 7 pertain to a combination coating and creping instrumentality. Here the cylinder **10**, suitably journaled in the frame of the machine and driven, is provided with a doctor support **13**, doctor **11** and strand tensioning means **17** hereinabove described. The direction of rotation of the cylinder is indicated by the arrow. The coating substance is fed to the bite by the spout **22** and travels along the bite in the mass **23** being removed as aforesaid at the exit end of the bite. A flexible web **47** is brought against the residual film and pressed against the surface of the cylinder by a pressure roll **48**. The web **47** may be creped or uncreped. The position of the pressure roll **48** may be varied to allow adequate time for the tempering of the film if desired before the web **47** is led against it.

The creping instrumentality comprises a creping knife **49** having a rear support **50** generally similar to the support **13** hereinabove described. This support is suspended from a beam **51** by means indicated at **52**. The creping knife support has a beveled front end and an abutment **53** and there is a tensioning strand **54** for holding the leading edge of the creping knife down onto the surface of the cylinder. The arrangement is somewhat similar to arrangements shown in United States Patent 2,567,967 in the name of applicant. The web **47** is removed from the surface of the cylinder and creped by means of the creping doctor **49**, as shown at **47*a***.

It will be noted in the apparatus of FIGS. 5, 6 and 7 that the coating doctor and the creping knife are both helically disposed and are substantially parallel with each other. The manner of mounting and the tensioning means employed are similar so that the conformation of the leading edge of the coating doctor and the leading edge of the creping knife to the surface of the cylinder is substantially identical. This is one important aspect of coaction, since the residual film is formed on the surface of the cylinder by means having substantially the same conformation to that surface as the means by which the residual film is subsequently removed from that surface in association with the flexible web. Furthermore, the distance of travel of any portion of the residual film from the point at which it is formed to the point at which it is removed

is substantially identical, which is important where the film is changed in consistency, as by the temperature of the cylinder between the point of formation and the point of removal. The build-up of undesired thicknesses of residual film is avoided. A constant thickness film is formed and a constant thickness film is removed, minimizing carry-over from the creping line to the coating line. If any portion of the residual film remains on the surface of the cylinder after the web is removed by creping, such portion will not only be small but will be uniform across the face of the cylinder surface and may be compensated for in the operation.

It may be noted that in the practice of the invention one aspect is the preferable use of a flexible shearing-type of applicator means held against the traveling surface in such a way that it applies a yielding radial pressure, a flexible diagonal doctor being one way of accomplishing this. Another important aspect of the invention is the enforced travel of a working mass of coating substance transverse the moving surface on which the residual film is being formed. Thus, the working mass is continually renewed with fresh substance, and any unused surplus is removed after it has traveled across the moving surface.

Modifications may be made in the invention without departing from the spirit of it. Having thus described the invention in exemplary embodiments, what is believed to be new and is desired to be secured by Letters Patent is:

1. In coating apparatus, in combination, means presenting a moving surface on which a residual film is to be formed, doctor means having a reaction at an angle to the direction of movement of said moving surface, and coacting with said moving surface to form a bite in which a coating substance may be maintained, means for delivering a coating substance to said bite at one end thereof, the said reaction of the said doctor means causing said coating material to travel along said bite across said moving surface to the other end of said bite, and means for removing from said surface the residual film thereof formed by said doctor means thereon.

2. Apparatus as claimed in claim 1 including means for removing excess coating substance from the other end of said bite.

3. Apparatus as claimed in claim 1 wherein said means presenting a moving surface is a rotating cylinder and wherein said doctor means is a knife substantially helically disposed with respect to said cylinder.

4. Apparatus as claimed in claim 1 wherein said means presenting a moving surface is a rotating cylinder and wherein said doctor means is a knife substantially helically disposed with respect to said cylinder, said knife being flexible and having tensioning means causing its contacting edge to be juxtaposed to the surface of the cylinder under substantially constant yielding radial pressure.

5. Apparatus as claimed in claim 1 wherein said doctor is a moving means and wherein the travel of said coating substance along said bite is enforced in part at least by a movement of said doctor transverse the direction of movement of said moving surface.

6. Apparatus as claimed in claim 1 wherein said doctor is a moving means and wherein the travel of said coating substance along said bite is enforced in part at least by a movement of said doctor transverse the direction of movement of said moving surface, said doctor being in the form of an endless metallic band and being provided with tensioning means for causing its contacting edge to conform to said moving surface, said moving surface being the surface of a cylinder, and said doctor contacting the said surface along a substantially helical line.

7. In apparatus of the character described, a driven cylinder, a flexible knife having a contacting edge juxtaposed to said cylinder along a substantially helical line, a support for holding the other edge of said knife away from said cylinder a tensioned strand contacting said knife adjacent its contacting edge for causing said knife to exert a substantially uniform yielding radial pressure against said cylinder across its surface, the contacting edge of said knife and said cylinder surface forming a bite in which coating material may be maintained for the formation of a residual film on said cylinder surface, means for delivering coating material to one end of said bite and means for removing excess coating material from the other end of said bite.

8. Apparatus as claimed in claim 7 wherein said knife releases said coating material at a point short of the edge of said cylinder and wherein said excess removing means comprises a scraper having a leading edge juxtaposed to the surface of said cylinder beyond said point and along a line substantially parallel with the cylinder axis.

9. In combination, means presenting a moving surface, a knife having a contacting edge juxtaposed to said surface so as to form a bite for coating material, the contacting edge of said knife following a line across said moving surface at an angle other than normal to its direction of motion, means for feeding coating material to one end of said bite and means for removing excess coating material from the other end of said bite, means for leading a web of flexible material into contact with a residual film of said coating substance formed on said moving surface, and means for removing said web and residual film from said moving surface, said last mentioned means being a knife having a leading edge substantially parallel with the contacting edge of said doctor.

10. Apparatus as claimed in claim 9 in which said means for presenting a moving surface is a driven cylinder and in which said knife and doctor have contacting edges substantially helically disposed to the surface of said cylinder.

11. Apparatus as claimed in claim 9 in which said means for presenting a moving surface is a driven cylinder and in which said knife and doctor have contacting edges substantially helically disposed to the surface of said cylinder, and in which said knife and doctor are each flexible members having means tensioning them against the surface of said cylinder under yielding radial pressure which is substantially constant across the surface of said cylinder.

12. A process of forming residual films for coating which comprises providing a moving surface and a doctor approached thereto to form a bite in which coating material may be maintained, said doctor having a reaction at an angle to the direction of movement of said moving surface whereby coating material in said bite is caused to travel therealong across said moving surface feeding coating material to one end of said bite and producing therein a continuous travel of said coating material along said bite toward the opposite end thereof, a certain quantity of said coating material passing between said doctor and said moving surface to form a residual film on said surface, and removing excess coating material from the opposite end of said bite.

13. The process claimed in claim 12 including the steps of causing said doctor to exert throughout its length a substantially constant, uniform, yielding pressure on said surface whereby the uniformity of said residual film is maintained, and controlling the thickness of said residual film by controlling the angle formed between said moving surface and the leading edge of said doctor, said pressure, and the viscosity of the said coating material.

14. The process claimed in claim 13 wherein the travel of said coating material along said bite is effected by disposing said bite at an angle other than normal to the direction of motion of said surface.

15. The process claimed in claim 13 wherein the motion of said coating material along said bite is effected in part at least by moving said doctor in a direction transverse to the direction of motion of said surface.

16. The process claimed in claim 13 including the step

of leading a flexible web onto the said residual film and afterward removing said flexible web and said residual film from said moving surface.

17. The process claimed in claim 16 wherein the said web and film are removed from said surface by creping means juxtaposed to said surface along a line all points of which are substantially equidistant along said surface from the corresponding points of contact of the said doctor and said surface measured in the direction of motion of said surface.

18. The process claimed in claim 13 including the step of tempering the residual film while on said moving surface so as to alter the characteristics thereof after the formation of said film.

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