May 25, 1965 C. W. DAMES, JR 3,184,828

# ROLL COVERS

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FIG. 1

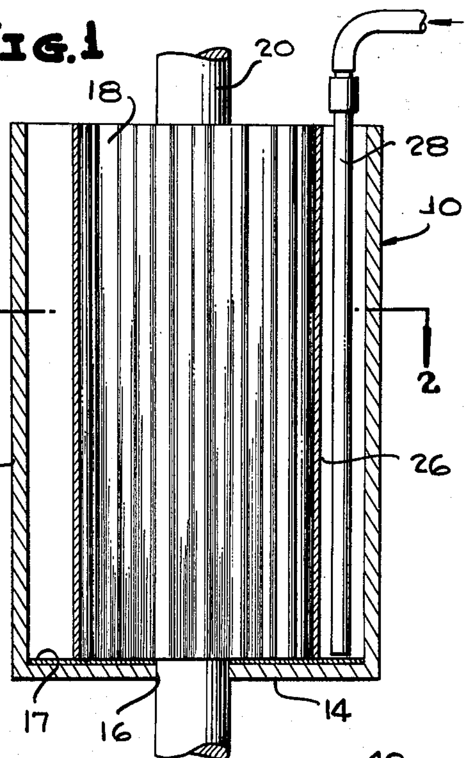



FIG. 3

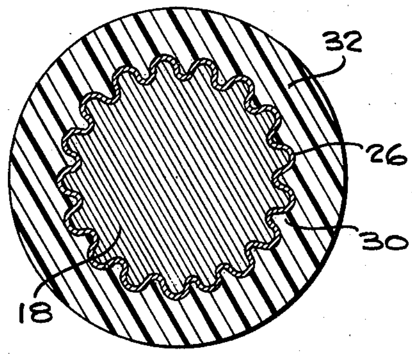
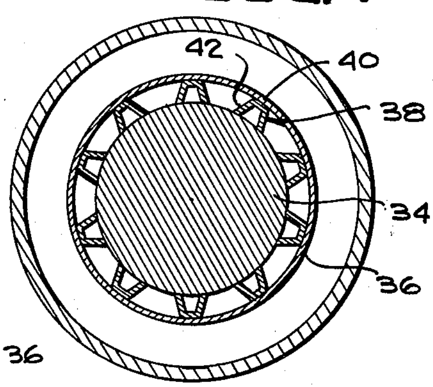



FIG. 4



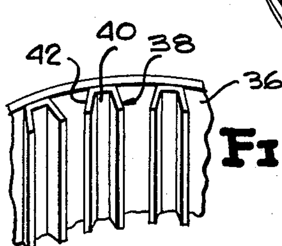
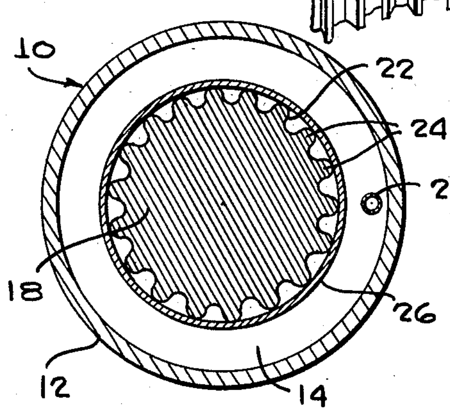
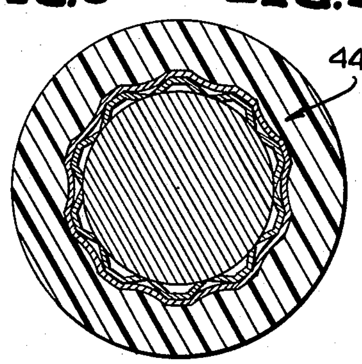




FIG. 6

FIG. 2

FIG. 5

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ROLL COVERS

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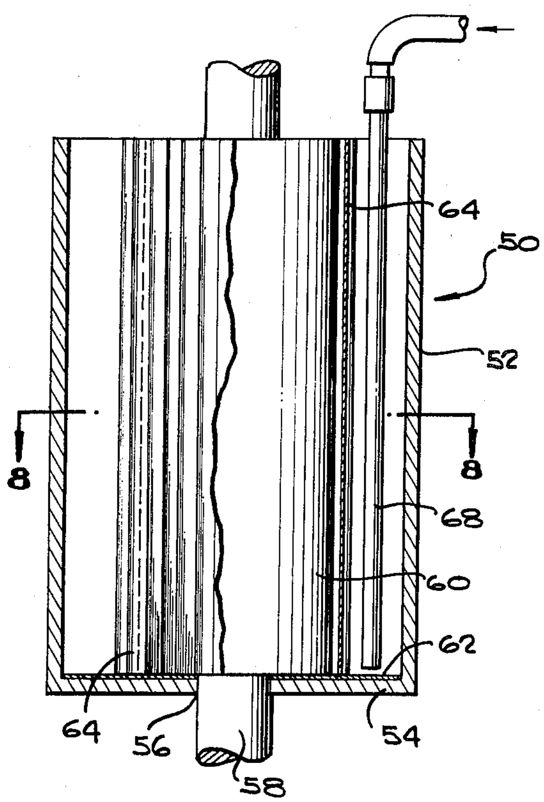



FIG. 7

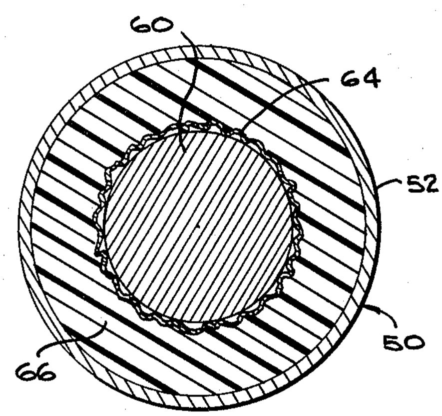
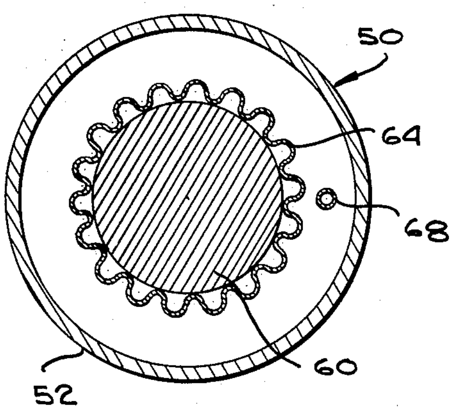



FIG. 9

FIG. 8

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United States Patent Office

3,184,828
Patented May 25, 1965



# 3,184,828
# ROLL COVERS

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Filed Nov. 30, 1962, Ser. No. 241,305
15 Claims. (Cl. 29—129)

This invention relates to improvements in roll covers, and, more particularly, to covers comprised of polylactams and methods for applying the same to a roll.

The invention is directed particularly to the formation of substantially stress-free polylactam roll covers by utilizing low temperature anionic polymerization processes for casting the polylactam covers, in situ, over the rolls. Rolls having these polylactam covers are particularly well adapted for use, for example, as back-up rolls against which paper articles may be cut; printing rolls; paper drive rolls; hold-down rolls for use in the steel industry; and rolls for various uses in embossing, calendering, and otherwise pressing deformable soft goods.

Due to the volumetric and/or thermal shrinkage that occurs during the polymerization of lactams, stresses are developed in the polymerizing material as it shrinks around the roll. While some degree of shrinkage is desirable to enable firm attachment of the cover to the roll, unduly high stresses must be relieved or they will cause fracture of the polylactam roll as, for example, by stressing and crazing.

Accordingly, it is an object of this invention to provide rolls covered with a substantially stress-free polylactam cover.

It is a further object of this invention to provide methods and means for preparing substantially stress-free polylactam roll covers by the in situ polymerization of polylactams around a roll.

And yet a further object of this invention is to provide methods and means for the relaxation of stresses developed during the polymerization of polylactams about a core piece.

The invention will be best understood from a consideration of the following detailed description taken in connection with the accompanying drawings, wherein:

FIG. 1 illustrates, somewhat diagrammatically, a mold and a roll enclosing sleeve, in longitudinal section, with the roll shown in elevation and showing, also, a means for introducing into the mold the hereinafter described lactam or lactams which form upon polymerization, the polylactam cover on and around the roll.

FIG. 2 is a cross sectional view, on an enlarged scale, taken substantially on the line 2—2 of FIG. 1.

FIG. 3 is a cross sectional view of the roll, the roll cover, and sleeve and showing the deformation of the sleeve.

FIG. 4 is a view in cross section of a smooth surfaced roll and illustrating another embodiment of the invention wherein the roll enclosing sleeve carries upon its inner surface bendable stand-off clips.

FIG. 5 is a cross sectional view of the roll, and sleeve shown in FIG. 4 and showing also in section, the applied polylactam cover and illustrating the deformation of the stand-off clips.

FIG. 6 is a detail, in perspective, of a portion of the sleeve shown in FIG. 4, showing the form of the stand-off clips.

FIG. 7 is a view similar to FIG. 1 but showing another embodiment of the invention wherein a smooth surfaced roll has a corrugated sleeve thereon.

FIG. 8 is a sectional view taken transversely of the structure shown in FIG. 7 substantially on the line 8—8.

FIG. 9 is a transverse section through the roll and corrugated sleeve and through the polylactam cover, illustrating the deformation of the corrugated sleeve.



The roll sleeve is a polymerized lactam such as nylon, prepared by low temperature polymerization. By low temperature polymerization is meant polymerization taking place below the melting point of the polymer and above the melting point of the monomer.

The low temperature anionic polymerization of lactams referred to above is disclosed, for example, in U.S. Patents 3,015,652; 3,017,391; 3,017,392 and 3,018,273.

Briefly, the above patents disclose the novel polymerization of higher lactams, i.e. lactams containing at least 6 carbon atoms in the lactam ring, as for example, e-caprolactam, enantholactam, caprylolactam, decanolactam, undecanolactam, dodecanolactam, pentadecanolactam, hexadecanolactam, methylcyclohexanone isoximes, cyclic hexamethylene adipamide, and the like, and mixtures thereof; in the presence of an anionic polymerization catalyst, as for example, alkali and alkaline earth metals such as lithium, sodium, potassium, magnesium, calcium, strontium, etc., either in metallic form or in the form of hydrides, borohydrides, oxides, hydroxides, carbonates, etc., organo-metallic derivatives of the foregoing metals, as well as other metals, such as butyl lithium, ethyl potassium, propyl sodium, phenyl sodium, triphenylmethyl sodium, diphenyl magnesium, diethyl zinc, triisopropyl aluminum, diisobutyl aluminum hydride, sodium amide, magnesium amide, magnesium anilide, Grignard reagent compounds, such as ethyl magnesium chloride, methyl magnesium bromide, phenyl magnesium bromide, and the like, and a promoter compound such as organic isocyanates, ketenes, acid chlorides, acid anhydrides, and N-substituted imide having the structural formula

$$\underset{\displaystyle R}{A-N-B}$$

wherein A is an acyl radical such as carbonyl, thiocarbonyl, sulfonyl, phosphinyl and thiophosphinyl radicals, B is an acyl radical of the group A and nitroso, R is a radical such as A, hydrocarbyl, and heterocyclic radicals and derivatives thereof, wherein said radicals in turn can contain radicals such as carbonyl, thiocarbonyl, sulfonyl, nitroso, phosphinyl, thiophosphinyl, tert.-amino, acylamido, N-substituted carbamyl, N-substituted carbamido, alkoxy, ether groups and the like, A and B, or A or R, together can form a ring system through a divalent linking group, and any free valence bond of the A and B radicals can be hydrogen or R, excepting A directly linked thereto, and the promoter compound preferably has a molecular weight of less than about 1000.

This polymerization of the higher lactams is initiated at temperatures of from about the melting point of the lactam monomer to about 250 C., and preferably from about 125° to about 200° C. As the reaction is exothermic, the initiation temperature will be exceeded under most conditions. The amount of catalyst and promoter compound each can vary from about 0.01 to about 20 mole percent, preferably from about 0.05 to about 5 mole percent, and more preferably still from about 0.1 to about 1 mole percent, all based on the higher lactam being polymerized. The higher lactams preferably contain from 6 to 20 carbon atoms and more preferably contain from 6 to 12 carbon atoms. The anionic catalyst preferably is a Grignard compound or an alkali metal and hydrides thereof. It will be understood that the anionic catalyst can be reacted in stoichiometric amount with a higher lactam to form a salt thereof, such as sodium caprolactam and said salt can then be employed in the polymerization process in an equivalent amount to the anionic catalyst as set out hereinabove. This preliminary preparation is particularly desirable as it permits ready removal of hydrogen gas from the system as when sodium or sodium hydride is employed, removal of water as when sodium hydroxide is employed, removal of water and carbon dioxide as when sodium carbonate is employed, etc. Isocyanates and N-substituted imides are the preferred promoter compounds. It will be understood that the use of acid chlorides effects the presence of HCl in the system which preferably is removed therefrom to preclude reaction with the anionic catalyst, whereby extra catalyst would otherwise be required. Similarly acid anhydrides generate organic acids in the system which then require sufficient anionic catalyst to neutralize the organic acid in addition to the amount desired to function in the polymerization reactions.

In carrying out the present invention the nylon cover is applied to a roll or similar body by means of a suitable mold in which the roll is positioned and into which the lactam monomer, conditioned for polymerization, as hereinafter described, is introduced.

In accordance with one aspect of the invention, where the nylon cover is applied to a roll body, the surface of the roll is initially longitudinally grooved whereby to effect, as hereinafter described, the tight encasement of the roll by the nylon, in a condition free of stress.

Referring particularly to FIGS. 1 and 2 of the drawings, the numeral **10** generally designates a mold into which the lactam is introduced. This mold is here illustrated as being in the form of a cylinder of the required size to receive the roll around which the nylon sleeve is to be formed.

The cylindrical wall of the mold is designated **12** and the mold is here shown as having a bottom **14** and since the roll is illustrated as having end journals, the bottom wall of the mold is shown as having an opening **16** whereby the lower end of the roll may be supported in the mold by or upon the bottom wall of the latter.

A suitable gasket is located upon the bottom wall of the mold, upon which the lower end of the roll may rest. This gasket may be formed of any suitable material, such as polytetrafluoroethylene, or the like, and functions to prevent the lactam from covering the lower end of the roll. This gasket or seal interposed between the bottom end of the roll and the bottom of the mold, is generally designated **17**.

The roll to which the cover is applied, is generally designated **18** and as shown it has the end trunnions **20**.

The roll face is provided with the longitudinally extending flutes **22** whereby there are formed the longitudinal splines **24**.

Around the splined roll is placed a sleeve **26** of a light gauge sheet metal and of a suitable soft or ductile character into the flutes or grooves of which the sleeve is pressed or deformed, under the force exerted radially of the roll by the polymerizing lactam due to the contraction or shrinkage which occurs in the reaction.

The lactam may be in one of several conditions, as illustrated in the following examples, when it is introduced into the mold. Accordingly, the following examples are set forth.

*Example I*

The lactam containing the initiator or promoter and the catalyst is heated to about 160° C. to start the reaction.

When the reaction begins and polymerization is started, the mix is introduced into the mold.

To facilitate the introduction of the mix in a manner to prevent formation of bubbles which might be held in the completed nylon cover, a tube or pipe such as that indicated at **28** may be extended to the bottom of the mold and through this the mixture is introduced and the pipe will be gradually withdrawn as the mold fills. This procedure prevents the development of turbulence which might otherwise produce bubbles which would be trapped in the finished nylon cover.

Preferably the flutes or grooves are of uniform size all around and are relatively small so that the stress will be uniformly distributed around the roll and against the sleeve **26**.

The area of the grooves may be determined by calculating, or otherwise determining, the volume of the mold and allowing for shrinkage of the cover on completion of the polymerization of the lactam. This shrinkage may vary considerably depending on the mold configuration and surface adhesion to the mold walls.

*Example II*

The epsilon caprolactam monomer containing the initiator or promoter and the catalyst is poured into the mold without preliminary heating. The mold may then be heated by any suitable means to raise the temperature of the mix and after the reaction has started it will go to completion in the mold as in Example I.

*Example III*

The epsilon caprolactam monomer having only the initiator or promoter therein is introduced into the mold after first being heated to raise the temperature thereof to approximately 170° C. The catalyst is then introduced. The 170° C. temperature is above that where polymerization starts and accordingly when the catalyst is introduced the polymerization reaction will commence and go to completion in the manner above stated.

When the polymerization reaction goes to completion and the shrinkage takes place, the radial stress applied to the sleeve **26** will bend or distort the sleeve into the flutes or grooves as indicated at **30**, thus relieving the stress and leaving the cover **32** relatively stress free.

As hereinbefore stated the light gauge sheet metal sleeve may be of any suitable ductile material such as soft aluminum, lead or other suitable yieldable metallic or non-metallic material.

In place of grooving the roll and enclosing the same in a sleeve or cylinder in the manner illustrated in FIGS. 1 to 3, whereby the yieldable or distortable sleeve is forced or pushed into the grooves as the polymerizing or crystallizing action occurs, the smooth or ungrooved surface of the roll may have interposed between it and a sleeve of soft yieldable material, a plurality of light gauge bendable spacer members or clips which will yield and spread as the radial compressive force is applied during the crystallization of the reacting material.

FIG. 4 illustrates a smooth surfaced roll, in cross section, generally designated **34**. This roll when placed in the mold **12** has placed about it a light gauge readily deformable sleeve **36**, corresponding to the hereinbefore described sleeve **26**, and this sleeve **36** has secured to its inner surface a plurality of longitudinally extending strips **38** of channel form. These strips **38**, of thin readily bent or deformable metal have the central back portions **40** thereof secured or joined to the inner surface of the sleeve **36** with the leg portions **42** extending in divergent relation toward and resting against the smooth surface of the roll as shown in FIG. 4.

As the polymerizing or crystallizing lactam mix contracts in the mold around the outer side of the sleeve **36** the radial stress applied to the sleeve will distort and force the sleeve **36** inwardly toward the roll and at the same time the pressure applied to the channel strips **38** will cause the legs **42** of the strips to spread apart so that the stress will gradually be relieved.

FIG. 5 illustrates a cross section corresponding to FIG. 4, of the roll, the sleeve and the nylon cover, illustrating the action described wherein the yieldable channeled strips **38** are distorted toward a flattened condition. The nylon cover is here generally designated **44** and as shown, where any in-blowing of the sleeve occurs, the nylon material will follow as illustrated.

FIGS. 7, 8, and 9 illustrate the method of carrying out the present invention by employing a corrugated sleeve of thin soft or ductile metal around the smoothed roller.

In these figures the numeral **50** generally designates the mold which is here shown, as in the preceding figures, as being in the form of a circular cylinder. The side or vertical wall of the mold is designated **52** while the bottom is designated **54** and is shown as having an opening **56**, if required, through which a trunnion **58** at the end of the roll **60** may extend.

The numeral **62** designates the sealing gasket interposed between the bottom of the mold and the bottom end of the roll.

In this embodiment of the invention the roll is or may be smooth surfaced.

The numeral **64** designates the sleeve of thin metal. This sleeve, as shown in FIG. 8, most clearly, is corrugated or fluted longitudinally.

The corrugated thin metal sleeve in effect combines in this embodiment of the invention, the functions of the corrugations or flutes formed in the surface of the roll and of the light gauge readily bendable or deformable spacer members or strips **38**.

When the nylon material shrinks or contracts after being introduced into the mold **50**, the flutes or channels of the sleeve **62** on the roller side of the sleeve provide the spacing which is taken up by the crushing or compressing of the sleeve, to relieve the stress or strain built up in the nylon cover.

FIG. 9 illustrates the nylon cover, in cross section. The cover is here designated **64** and it will be seen that the sleeve **66** has the flutes thereof mashed or deformed. Thus the stress of the sleeve will be relieved so as to leave the sleeve relatively stress free and the crumpled or compressed form of the sleeve will also establish a tight or strong coupling between the sleeve and the surface of the roll.

In these last figures the numeral **68** designates the filling tube which, as hereinbefore stated, is gradually withdrawn as the mixture is introduced and the mold fills, so that the formation of air spaces or bubbles in the cover is avoided.

It will be seen from the foregoing that the invention here illustrated and described provides a roll cover of nylon which is comparatively stress-free. If undue stresses are not relieved in the roll, it will crack and stress-craze in operation or when the roll is being machined to dimensional tolerances. On the other hand, it is not always desired that the cover be completely relieved of all stress as it is desired that a force be exerted by the roll cover against the roll in order to lock it into position so that there will be no relative motion between the roll and the cover in operation, such as in the calendering of paper.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents, are therefore intended to be embraced by those claims.

I claim:

1. The method of applying a substantially stress free nylon cover to a metal body such as a roll, a shaft, and the like, which comprises enveloping the part of the body to be covered in a lactam, effecting polymerization of the lactam, and effecting absorption of inwardly directed radial stresses resulting from shrinkage of the polymerizing lactam, by means of a deformable structure interposed between the body and the lactam.

2. The process according to claim 1, wherein the said polymerizing of the lactam is started immediately prior to envelopment of the body and allowed to go to completion during said envelopment, to form the nylon cover on the body.

3. The invention according to claim 2, wherein the lactam is first mixed with a promoter, with the mixture



heated to a temperature insufficient to start polymerization but sufficient to start such polymerization after introduction of a catalyst thereinto, and then introducing a catalyst and utilizing the heat of exothermic reaction to increase the temperature of the mix for completing the polymerization of the lactam to form the nylon cover on the body.

4. The method of applying a substantially stress free nylon cover to a metal body such as a roll, a shaft and the like, which comprises enveloping the part of the body to be covered in a lactam confined in a molding area, effecting the heating of the lactam with a promoter and a catalyst therein, while so confined to initiate polymerization of the lactam, and effecting absorption of inwardly directed stresses resulting from shrinkage of the polymerized lactam, by means of a deformable material interposed between the lactam and the body to obtain a stress free cover on the body.

5. The method of applying a substantially stress free nylon cover to a metal body such as a roll, a shaft, and the like, which comprises positioning the body in a molding chamber, introducing a lactam into the chamber to envelope the portion of the body to be covered, effecting polymerization of the lactam in the chamber and effecting the absorption of inwardly directed stresses in the polymerizing material resulting from shrinkage thereof, by interpositioning between the body and the lactam a thin sleeve of deformable material and maintaining such sleeve with a predetermined spacing between it and the body, into which spacing the sleeve deforms under imposition of said stresses thereon.

6. The method according to claim 5 with the step of forming recesses in the surface of the body to provide the said spacing.

7. The method according to claim 5, with the step of positioning bendable stand-off elements between the sleeve and the body to provide the said spacing.

8. The method according to claim 5 with the step of forming grooves in the surface of the body to provide the said spacing.

9. The method of applying a substantially stress free nylon cover to a metal body such as a roll, a shaft and the like, which comprises positioning the body in a mold chamber, introducing into the chamber a mix of a lactam containing an initiator or promoter and a catalyst to envelope the part of the body to be covered, heating the mix in the chamber to start the polymerization action, and relieving at least a portion of stresses created by shrinkage of the polymerizing mix by having interposed between the mix and the body and spaced at least in part from the body, a separator of a yieldable and deformable material.

10. The method of applying a substantially stress free nylon cover to a metal body such as a roll, a shaft, and the like, which comprises positioning the body in a mold chamber, preparing a mix of a lactam, an initiator or promoter and a catalyst, heating the mix to a temperature of about 160° C. to start the polymerization reaction, then introducing the mix into the chamber to envelope the part of the body to be covered and allowing the exothermic reaction heat to complete the polymerization of the lactam in the chamber, and absorbing at least a portion of stresses created by shrinkage of the polymerizing mix by having interposed between the mix and the body and spaced at least in part from the body, a separator of a yieldable or deformable material.

11. The method of applying a substantially stress free nylon cover to a metal body such as a roll, a shaft and the like, which comprises positioning the body in a mold chamber, introducing into the chamber a mix of a lactam and a promoter heated to a temperature of at least 170° C. to envelope with the mixture the part of the body to be covered, then introducing a catalyst into the heated lactam and promoter mixture to start the polymerization reaction and maintaining the reaction to completion, and

absorbing stresses created by shrinkage of the polymerizing mix by having interposed between the mix and the body and spaced at least in part from the body, a separator of a yieldable and deformable material.

12. A roll body, a sleeve on and enclosing the body, and a stress relieved nylon cover overlying the sleeve and locked to the roll body by deformations in the sleeve in which complementary portions of the nylon are engaged.

13. A roll body, a sleeve on the body, and secured thereto under compression, and a substantially stress free nylon cover surrounding the sleeve and maintaining said compression of the sleeve against the body and said cover being locked to the body through the medium of the sleeve by areas of deformation resulting from shrinkage of the cover, the said areas of deformation in their development during said shrinkage providing relief of stresses in the nylon cover.

14. The method of forming a void free nylon cover on and around a body, which comprises positioning the body in a mold, introducing a filling tube into the mold to extend the full depth of the latter, then introducing nylon forming mixture of a lactam monomer, a catalyst and an initiator into the mold through the tube, withdrawing the tube as the mold fills and thereby avoiding formation of voids or air spaces in the mixture to be trapped in the polymerization of mixture.



15. The method of applying a stress free nylon cover to a metal body such as a roll, a shaft, and the like, which comprises positioning the body in a molding chamber, introducing a lactam into the chamber to envelope the portion of the body to be covered, effecting polymerization of the lactam in the chamber and effecting the absorption of inwardly directed stresses in the polymerized material resulting from shrinkage thereof, by interpositioning between the body and the lactam, a thin longitudinally corrugated sleeve of readily deformable material to be compressed and distorted under stresses imposed thereon in the shrinking of the polymerizing lactam.


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