Feb. 4, 1969 F. M. CHAPMAN ET AL 3,426,119

COVERING OF ROLLS WITH FLUORINATED ETHYLENE POLYMERS AND THE LIKE

Filed June 23, 1965

Sheet 1 of 2

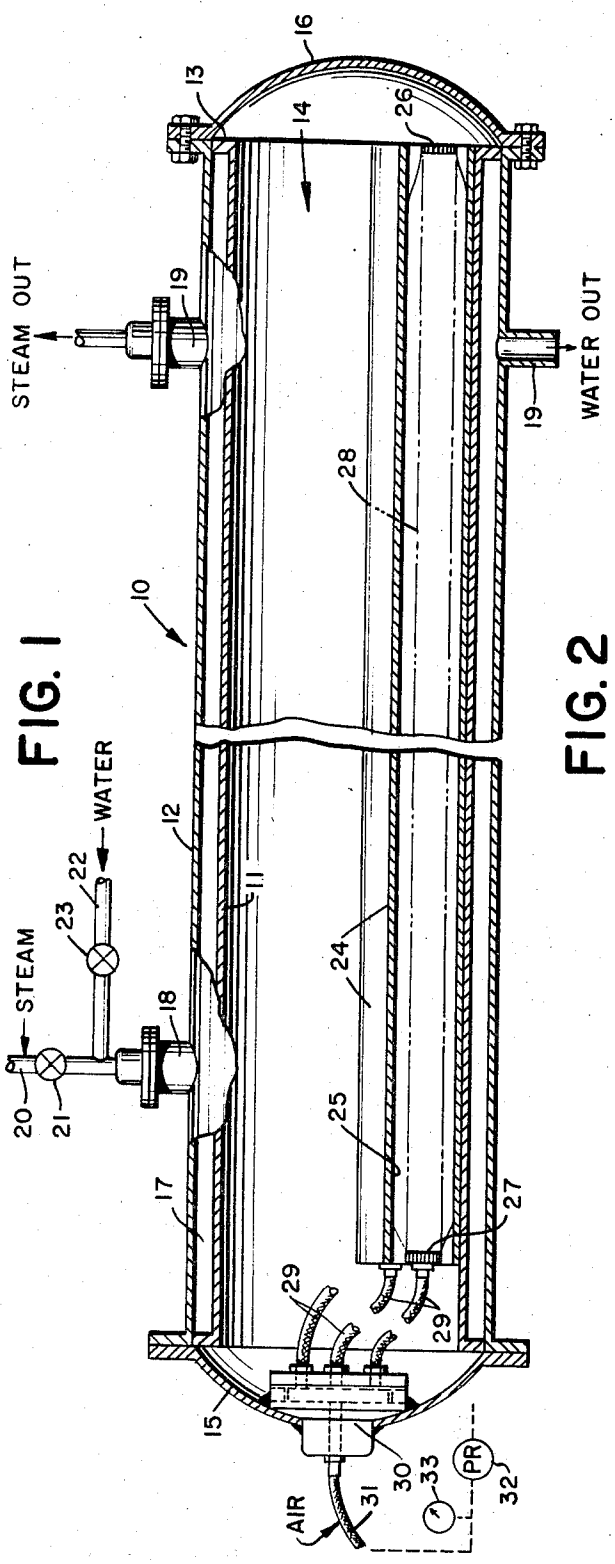


FIG. 1

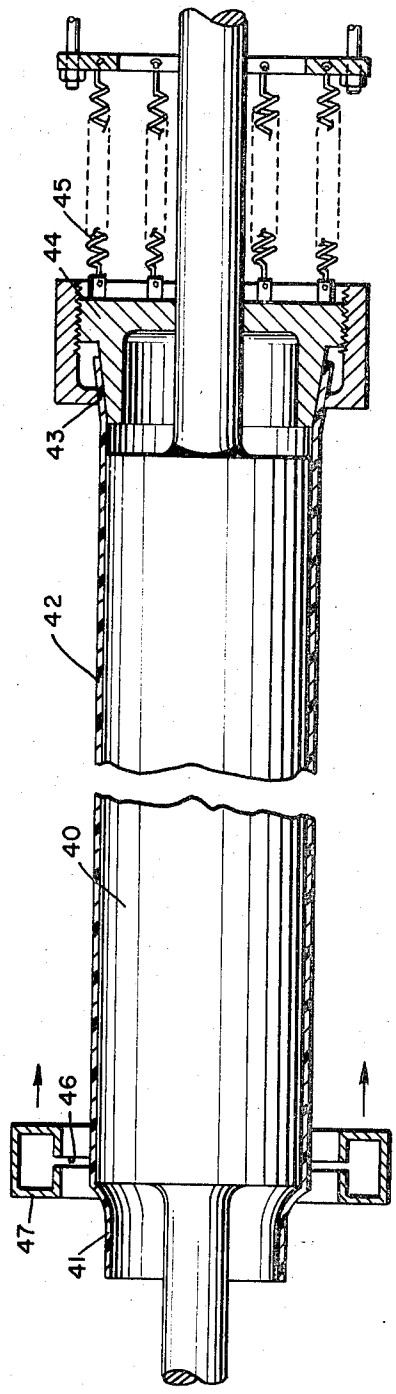


FIG. 2

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FIG. 3

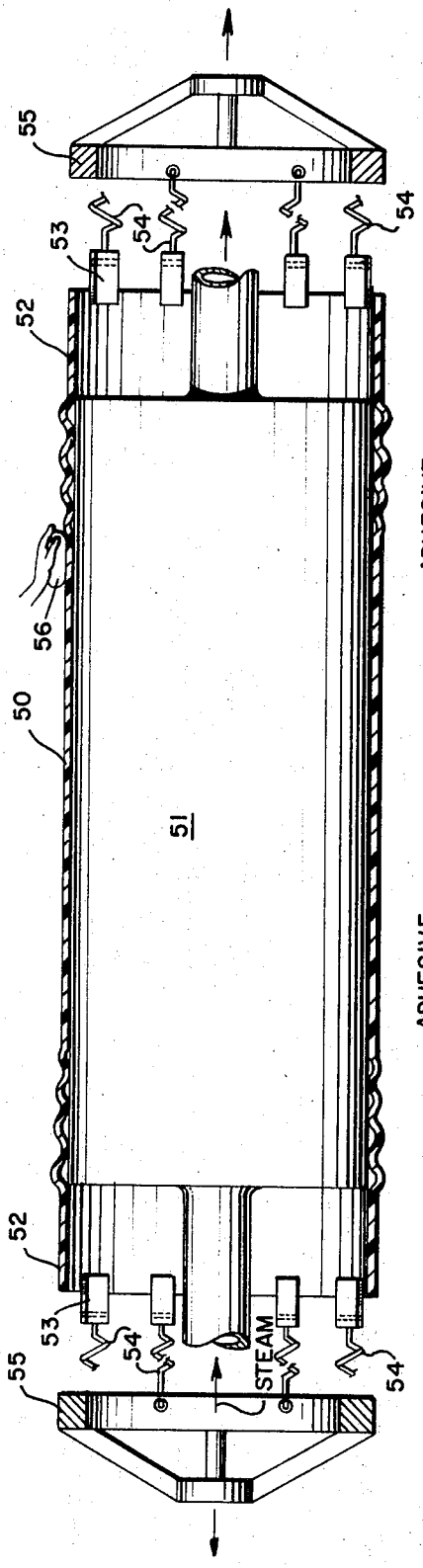


FIG. 4

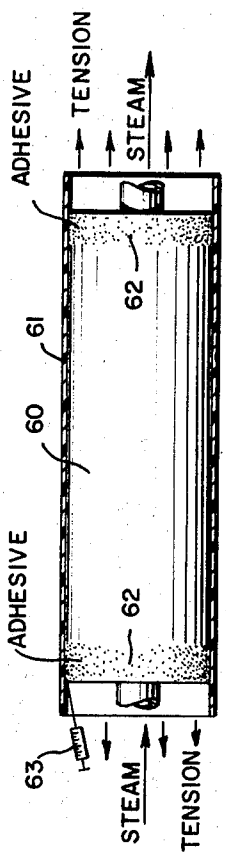
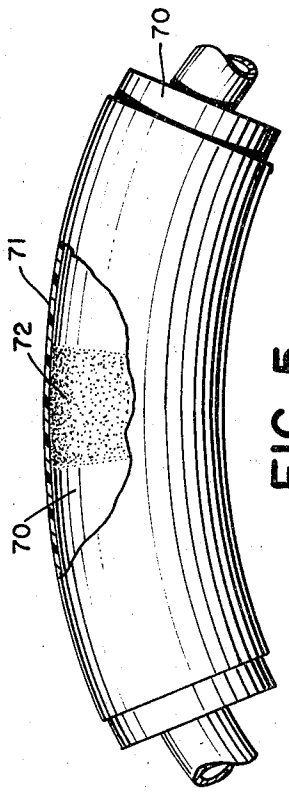


FIG. 5



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3,426,119

COVERING OF ROLLS WITH FLUORINATED ETHYLENE POLYMERS AND THE LIKE

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U.S. Cl. 264—230 3 Claims
Int. Cl. B29c 27/20

ABSTRACT OF THE DISCLOSURE

The invention is directed to an improved process for the installation on a roller surface of a heat-shrinkable, thermoplastic material, particularly including such materials as fluorocarbon polymers (e.g., Teflon FEP). The procedure comprises applying a heat-shrinkable tubing axially over the roll, seating, a necked-down portion of the cover at one end of the roll, applying axial tension to the cover material, and thereafter heat-shrinking the covering material progressively along the roll, starting from the necked-down end, while maintaining the covering under axial tension.

In the covering of rolls with fluorocarbon polymers and similar surfacing materials, one of the advantageous installation procedures involves the application about the roll of a tube of the covering material which, by previous conditioning, is heat-shrinkable in its radial or circumferential dimensions. After initially positioning the tube about the roll, heat is appropriately applied to the surfacing material, and the tube is caused to shrink down into tight fitting relation to the roll.

In accordance with one of the more specific aspects of the invention, novel and improved procedures are provided for preparatory processing of the covering material to form heat-shrinkable tubes. The procedures of the invention enable significant economies to be realized during processing and, at the same time, enable greater control and closer tolerances to be maintained throughout. Thus, in accordance with the invention, it is possible and practical to process simultaneously a plurality of tubes of covering material, in a manner enabling significant economies to be realized in equipment costs and production time. The contemplated procedures also facilitate the handling and manipulating of the tubes and equipment as compared to known procedures. In accordance with this aspect of the invention, improved procedures are provided for circumferentially or radially distending tubes of covering material, to impart heat-shrinkability.

In accordance with another specific aspect of the invention, the initial distention of the tube to impart heat-shrinkability advantageously is carried out in such a way as to form necked-down end sections on the tube. Prior to installation, one of the end sections is removed, while the other is retained on the distended tube. The necked-down end section facilitates subsequent installation and provides for improved uniformity in the product, as will appear.

One of the important fields of application for fluorinated polymer roll coverings is in connection with paper machine dryer drums, for example, and other important areas of utilization may involve drums or rolls of substantially size and/or rolls intended for operation at elevated temperatures. As a significant aspect of the invention, improved and advantageous procedures are provided for installing heat-shrunk film coverings for heated rollers and for large diameter rollers, whether or not intended for operation at elevated temperatures. In the case of hot service rolls, installation of the roll covering includes axial

elongation of the roll covering by thermal elongation and/or axial tension, such that the total elongation of the covering exceeds that which would be experienced by thermal elongation alone during normal service at intended elevated temperatures. While the covering is thus stressed, it is anchored at its ends to the roll. Thereafter, under all service conditions, the roll covering remains under axial tension.

Particularly with respect to internally heated rolls, such as paper machine dryer drums, heat-shrinking of the covering material onto the roll is most advantageously brought about utilizing heat imparted internally to the roll, accompanied by mechanical manipulation of the covering material and, if necessary, axial tension applied thereto, to provide a smooth, snug fitting surface covering as desired.

Other aspects of the invention include novel and advantageous techniques for special application coverings, such as involved in the provision of a fluorinated polymer surface covering for a bowed spreader roll (e.g., Mt. Hope-type), for example.

It will be understood that the invention is directed principally to the provision of roll coverings formed of fluorinated ethylene polymers, such as Du Pont's Teflon FEP, but that other similar materials are contemplated to be usable, such as materials now sold under the trademarks Kel-F, Aclar, Lexan, and the like.

For a more complete understanding of the invention, reference should be made to the following detailed description and to the accompanying drawing, in which:

FIG. 1 is a simplified schematic representation of an apparatus and procedure for preparing radially distended, heat-shrinkable tubes of fluorocarbon polymer, intended subsequently to be heat-shrunk on a roll surface;

FIG. 2 is a simplified schematic representation showing the manner of installing a roll covering such as made in accordance with the procedures illustrated in FIG. 1;

FIGS. 3 and 4 are sequential illustrative representations illustrating procedures according to the invention for installing a heat-shrunk fluorocarbon plastic polymer plastic covering to a large heated roller, such as a paper dryer drum; and

FIG. 5 is a schematic representation of a bowed spreader roll provided with a fluorocarbon polymer roll covering in accordance with the procedures of the invention.

In the preparation of fluorocarbon polymer surface coverings, it is necessary to provide, at some stage, a tubular covering element which has been radially distended to a predetermined degree such that, upon subsequent exposure to elevated temperatures, the material will tend to shrink back to its initial dimensions. Typically, the initial dimensions of the tube, or of the film from which the tube is constructed, may be on the order of 5 percent smaller than the dimensions of the roll to be covered. After distention, the dimensions of the tube may be on the order of 5 percent greater than the dimensions of the roll, representing an increase in the dimensions of the tube of about 10 to 15 percent. Upon subsequent exposure to heat, after application of the distended tube to a roll, the tub tends to shrink back to its initial dimensions but is, of course, limited by the dimensions of the roll, such that the tub is drawn snugly onto and about the roll surface, in the manner desired.

In the case of covered rolls of large diameter, the tube advantageously is formed by joining opposite end edges of a film section along a butt joint, by novel heat sealing techniques describd and claimed in our copending application Ser. No. 411,898. Heat-shrinking characteristics may be imparted to the tube by distending the film in its circumferential direction, either before or after joining

along the butt seam. Advantageous techniques for this purpose are covered in our beforementioned copending application. For roll coverings of smaller diameters, on the other hand, it is often advantageous to utilize extruded tubular sections. To impart the desired heat-shrinking characteristics to such extruded tubular sections, the tubes may be distended radially outward by means of applied fluid pressure, advantageously while the material is maintained at an elevated temperature. Certain aspects of the invention are directed to improved techniques for this purpose.

With reference now to FIG. 1 of the drawing, the reference numeral **10** designates generally an autoclave-like assembly including inner and outer chamber walls **11, 12** which are sealed by end flanges **13** to form a jacketed main chamber **14**, which is closed off at the ends by removable end closures **15, 16**. The outer jacket **17**, which completely surrounds the main chamber has appropriate fluid inlet and outlet connections **18, 19** through which appropriate heating and cooling media may be directed. Typically, the inlet may be connected to a steam source through an appropriate conduit **20** and control valve **21**, and with an appropriate source of cooling water through a conduit **22** and control valve **23**.

In accordance with a specific aspect of the invention, one or more elongated cylindrical forms **24, 25** are provided, which may be removably received within the autoclave main chamber **14**. It is contemplated by the invention, as will be further described, that a given processing operation may involve the utilization of a single cylindrical form within the autoclave chamber. Or, at the other extreme, it may involve as many individual cylindrical forms as may physically be accommodated by the interior configuration of the chamber.

The cylindrical forms **24** have an internal diameter corresponding substantially to the final outside diameter sought for in a distended, heat-shrinkable covering tube, as indicated generally by the numeral **25** in FIG. 1. Typically, this dimension will be some 10 to 15 percent in excess of the initial outside diameter of the tubing in its "as extruded' form.

In the process of the invention, as illustrated in FIG. 1, an elongated section of covering film, typically formed of Teflon FEP or other fluorocarbon polymer, is sealed at its opposite ends by means of suitable caps **26, 27** arranged to be securely clamped in place. Most advantageously, the end caps **26, 27** are of a size appropriate to be received readily over the ends of the tubing at its extruded diameter, as indicated by the phantom lines **28** in FIG. 1.

The end cap **27**, at one end of the tubing section **25**, is connected through a suitable hose **29** to a header **30**. The header is in turn connected through an air supply hose **31** and a pressure regulating valve **32** to a source of compressed air (not shown). A suitable pressure gage **33** also is typically provided downstream of the pressure regulating valve.

In the process according to the invention, one or more of the cylindrical forms **24** are loaded with capped tubes **25**, in an operation which advantageously, although not necessarily, is carried out outside of the autoclave chamber. One or more of the thus loaded cylindrical forms is inserted in the chamber, and, since there is no unbalanced force acting on the forms, it is not necessary to secure them in place. Typically, if a plurality of forms are inserted simultaneously into the autoclave chamber, the tubing sections contained therein would be of substantially identical specifications, so that all units could receive simultaneous processing under optimum conditions. However, it will be appropriate in many instances to process simultaneously tube sections of different length, diameter, and film thickness, as well as of different materials, as circumstances permit.

After loading of the cylindrical forms **24** into the autoclave chamber, the several distribution hoses **29** are connected between the header **30** and the individual tube sections **25**, and the autoclave chamber is closed up. In this respect, the chamber **14** is not placed under superatmospheric pressure, but only serves as an isolating chamber in which the ambient temperature may be controllably raised and lowered.

When the chamber **14** is closed up, pressure fluid is admitted into the interior of the individual tube sections, by manipulation of the pressure regulating valve **32**, so that each of the tubes is placed under internal pressure. The steam control valve **21** is at this time opened, so that steam flows through the jacketing chamber **17** to heat the ambient within the chamber.

By a combination of heat and internal pressure, the capped tubes **25** are caused to expand outward into conforming contact with the interior walls of the cylindrical forms **24**, substantially as shown in FIG. 1, the end sections of the tubes being necked-down, as indicated, because of the caps **26, 27** which retain the end extremities of the tubes at their initial, extruded diameters.

Optimum temperatures and pressures will, of course, be a function of the specific material utilized in the tube sections. Utilizing Teflon FEP, the temperature of the polymer material should be raised to a minimum of about 170° F. and, as a matter of convenience, the tempreature may be raised to a level of around 210° F.–230° F. The optimum internal pressure is a function, not only of the material, but also of the diameter of the tube and its wall thickness. By way of example, with Teflon FEP extruded tubes, an internal pressure of about 6 p.s.i. appears to be optimum in a 9 inch tube (10 mil wall thickness). Optimum internal pressure varies inversely with the diameter of the tubing and, for a 5 inch tube of the same wall thickness an expanding pressure of around 13 p.s.i. is appropriate.

After the pressurized tubes have been brought up to heat and have been uniformly distended into conforming contact with their respective cylindrical forms, the steam valve **21** is closed and the water control valve **23** is opened, to reduce the temperature of the chamber ambient below the "critical" level, which appears to be somewhere in the region of 170° F. In a repetitive production operation, instead of cooling the autoclave on each occasion, the individual cylindrical forms may simply be removed and cooled outside the chamber, by quenching if appropriate. Other loaded forms may be treated while the just-removed forms are cooled and unloaded.

The procedures of FIG. 1 are particularly advantageous and economical in that, with the single autoclave apparatus, it is possible and practical to process tubes of a wide variety of sizes and shapes and as well to process a large number of tubes, of the same or different kinds, at one time. The individual cylindrical forms **24** may be of an inexpensive, lightweight construction, so that it is not burdensome from the standpoint of capital investment or storage space to have available a large number of sizes and a number of each size.

In accordance with another aspect of the invention, advantageous techniques are provided for installing on a roll a distended tubing of the general type produced in the procedure of FIG. 1. Thus, with specific reference to FIG. 2, there is shown a roll **40** of predetermined diameter which is to be provided with a cover of fluorocarbon polymer such as Teflon FEP. For this purpose, a processed, distended tube section, as from the process of FIG. 1, has one of its necked-down end sections removed, while the other end section is retained, its end cap **26** or **27** having been removed. The tube at this stage consists of an elongated body section of substantially uniform internal dimensions and a necked-down end section **41** having a minimum diameter substantially smaller (e.g. 5 percent) than the diameter of the roll **40**.

Installation of the covering is initiated by applying the elongated body section **42** over the roll **40**, until the necked-down end section **41** engages the end of the roll. Thereafter, the open end of the tube, identified by the

numeral **43**, is engaged by a suitable gripper **44** and placed under axial tension, as by springs **45** or other appropriate means. When the tube is thus placed under tension, the necked-down end section **41**, having a tapered internal configuration, serves to bring the body of the tube into substantial concentricity with the roll **40** and also to provide form to the cylindrical body section **42** of the tube, so that the covering material is disposed uniformly over the surface of the roll.

For cold service applications, the axial tension applied to the distended tube section in FIG. 2 may be relatively light. For hot surface service or elevated temperature applications, however, it may be desirable to place increased tension on the covering tube, as will be explained in greater detail.

After the tube has been gripped and positioned as shown in FIG. 2, it is heat-shrunk into tight-fitting relation with the roll **40**, typically by directing streams of heated air onto the exterior of the body portion **42** of the tubing. By way of example only, the heated air may be directed through an annular slot **46** in a header **47** arranged to travel from one end to the other of the roll.

In carrying out the procedures of FIG. 2, it is most advantageous to utilize a distended tube processed in accordance with FIG. 1, or by any other process involving radial distention of the tube by internal pressure while maintaining sealing caps at the ends of the tube to form necked-down end sections. Thereafter, by the simple expedient of removing one of the necked-down end sections, the processed tubing is made ready for application according to the procedures of FIG. 2.

In FIGS. 3 and 4, there are shown other important aspects of our invention, having regard particularly to the covering of rolls which are of large diameter and/or are intended for operation at elevated temperatures. As an outstanding example, coverings according to the invention are advantageously utilized in connection with dryer drums for paper machine dryer sections, which may be on the order of 5 feet in diameter, say, and as much as 10 to 25 feet in length.

In the case of large diameter rolls, whether or not intended for service at high temperature, difficulty is experienced in achieving a uniform shrinkage of the tube onto the roll surface, because of the difficulty of achieving uniform application of heat to the covering film by conventional means and procedures. This is partly due to the large size of the roll, which presents certain manipulative problems with respect to the roll itself and also with respect to any heating facility applied thereto. In addition, the body of a large roll constitutes a massive heat sink, which makes it difficult to apply and to maintain adequate levels of heat in conventional ways.

According to one aspect of our invention, large diameter rolls which are capable of being internally heated in service may advantageously be heated in this manner in order to effect heat-shrinking of the covering film into taut relation about the body of the roll. Heretofore, the prior art has regarded a procedure of this type as being wholly inoperative and impractical because, without appropriate additional steps forming part of the invention, the film is caused to shrink down onto the roll surface in a mass of wrinkles and distortions, such as to be wholly unsuitable for use.

In accordance with the invention, and as illustrated particularly in FIG. 3, a fluorocarbon or similar polymer film, formed into a tube **50** and intended to be heat-shrunk about a large diameter roll body **51**, is applied over the roll and is arranged to have projecting portions **52** extending beyond the roll at each end. In accordance with the teachings of our beforementioned application, the tube **50** typically will be formed by butt joining the opposite ends of a length of film, either directly on the roll **51** or, where circumstances permit, at a separate location The resulting tube **50**, which may consist of a 10–20 mil film of Teflon FEP, for example, is radially (circumferentially) distended prior to its application to the roll, such that its distended diameter is, say, 5 percent greater than the diameter of the roll while its initial or normal diameter may be 5 percent less than the diameter of the roll.

As shown in FIG. 3, the projecting end sections **52** of the tube may be gripped by means such as clamping elements **53**, which are drawn axially by suitable means such as springs **54** and suspension brackets **55**. This arrangement, at each end, enables the tube **50** to be placed under a predetermined axial tension, the magnitude of which may be adjusted to the circumstances.

In accordance with the invention, a tube of Teflon FEP or similar material, in a radially distended, heat-shrinkable condition, is placed over the roll **51** and under axial tension. The roll **51** is then heated to a temperature above that at which the tube will shrink and below that at which it will melt or otherwise degrade. Advantageously, steam is utilized as the heating medium, to raise and maintain the temperature of the film in the 200–300° F. range.

When the roll **51** comes up to heat, the tube **50** will shrink down into tight contact with the roll surface. However, notwithstanding the use of applied axial tension, the tube will shrink down in a mass of wrinkles and distortions such that, at this stage, the covered roll may be entirely unfit for service. In accordance with the invention, however, while the heat and/or axial tension are contined to be applied to the tube, the film is manipulated on the roll in a way to "work" the wrinkles, entrapped air bubbles, etc., from the center area of the roll axially toward the ends. Even though the film has been shrunk by heat, it remains sufficiently workable and pliable while heat is continued to be applied to enable the necessary manipulations to be effected. Most advantageously, the proper manipulation and working of the heated tube is performed manually, as by rubbing the film with a pad **56**, simultaneously pressing radially inward on the pad and advancing it axially from the center toward the end of the roll. Advantageously, the tube is worked more or less in annular increments or stages such that, as the working progresses, the center annular areas of the roll will be covered by a perfectly smooth, wrinkle-free layer of the covering material.

Thus, as a significant aspect of the invention, although the applied tube of Teflon FEP or similar fluorocarbon material, when initially heat-shrunk down onto the roll **51** over its entire active surface by internal heating of the roll, initially may be a mass of wrinkles and may be wholly unsuitable for use, these imperfections can be entirely removed by manipulating and working the covering film, provided it is maintained at an elevated temperature and/or under longitudinal tension. This novel expedient has greatly reduced the time required to effect uniform, heat-shrunk application of film coverings to massive rolls, and has in some cases enabled the taks to be performed where it could not otherwise be performed by conventional techniques in an economically feasible manner.

In the case of rolls intended for hot service applications, such as dryer rolls or drums for paper machine dryer sections, drying or pressing rolls for fabric processing equipment, and the like, additional techniques of installation are required according to the invention, particularly in the case of covering materials such as Teflon FEP, whose coefficient of thermal expansion exceeds that of steel. Thus, with reference to FIG. 4 as being exemplary, there is shown a hot service roll **60**, such as a paper machine dryer drum, which is provided with facilities for being internally heated by steam or other medium. A surface covering tube **61**, generally as previously described, is applied over the roll **60** and is shrunk down onto the surface of the roll by appropriate techniques, advantageously by internal heating of the roll itself acccmpanied by proper working and manipulation of the covering film as described in connection with FIG. 3.

When the heat-shrunk film **61** has been worked and smoothed to be free of imperfections, while the roll and

covering film are maintained at an elevated temperature, and/or while the film is maintained under predetermined axial tension, end sections of the film are securely anchored to end areas of the roll. Most advantageously, the anchoring of film to roll is achieved through the use of a suitable thermosetting or other adhesive, which is applied between the film and the roll surface about a limited annular end area of the roll, substantially as indicated at **62** in FIG. 4. A typical thermosetting adhesive suitable for the purpose of bonding Teflon FEP fluorocarbon film to a steel roll may have a curing time of on the order of 30 minutes at the temperatures utilized (e.g., 150–250° F.). Accordingly, if the size and configuration of the roll and its covering are such as to permit or accommodate shrinkage and appropriate working out of the wrinkles and distortions within that time, a thermosetting adhesive may be applied prior to application of the radially distended film to the roll. In the case of rolls too large for this purpose, however, it is advantageous according to the invention to inject thermosetting adhesive between the film and roll end area after heating and working of the film, and a syringe-like device **63** may advantageously by utilized for this purpose. The axial extent of the annular band of adhesive at each end of the assembly advantageously is limited, and need not significantly exceed the minimum amount required to anchor the film securely and safely under service conditions.

In connection with the installation of a covering of Teflon FEP or similar material, having a thermal coefficient of expansion in the temperature range concerned which exceeds that of the material (usually steel) of which the roll itself is formed, it is particularly advantageous to maintain the roll and film at a temperature above those expected to be encountered in service during installation and anchoring of the film. Otherwise, in the absence of other compensatory operations, thermal expansion of the film in an axial direction, in service, could cause annular wrinkles to form in the covering material. Where practical considerations do not permit adequately high temperatures during installation and anchoring of the film ends, it is appropriate to apply axial tension to the film such that elongation under tension, in combination with the thermal expansion, will be sufficient to insure that the film is retained under at least some axial tension at all times during normal service conditions.

With the arrangement of FIG. 4, the roll covering **61** is smooth and taut not only after the initial installation and curing of the adhesive end areas **62**, but also after temperature cycling of the covered roll. In this respect, when the covered roll is cooled down, the tubular covering **61**, if formed of a material such as Teflon FEP having a higher thermal coefficient of expansion than the roll itself, would shrink lengthwise to a greater degree than the roll, causing the ends of the tubular covering to draw in. Thereafter, when the covered roll was reheated for use, the film would tend to re-expand axially and form wrinkles and other distortions. This is entirely obviated by the present invention by anchoring the end portions of the tubular covering and by providing for at least a minimum amount of axial tension in the covering when the roll is at service temperature.

In accordance with another aspect of the invention, heat-shrunk roll coverings of Teflon FEP fluorocarbon or similar materials may be utilized to advantage in the covering of bowed spreader rolls arranged for arcuate disposition. Thus, in FIG. 5, the reference numeral **70** designates a conventional bowed spreader roll arranged in an arcuate configuration, which may be fixed or, more likely, is adjustable from cylinder form to a predetermined maximum curvature. A roll covering film **71**, of Teflon FEP or the like, is applied axially over the roll **70** and is heat-shrunk into taut relation with the roll surface in accordance with procedures heretofore described in this and our copending application.

In the operation of a covered bowed spreader roll in its curved disposition, a tubular roll covering **71** secured solely by being heat-shrunk into taut relation about the roll surface will normally tend to work itself axially with respect to the roll body. Accordingly, some positive means is required for anchoring the shrunk tube **71** onto the roll surface in its initial, predetermined alignment. To this end, and in accordance with the invention, an annular region **72** of adhesive appropriate to the materials concerned is provided to join the central regions of the tube and roll, while the end regions are retained free of adhesive bond. The axial extent of the adhesive area **72** advantageously is as limited as is consistent with reliable anchoring of the tubular roll covering **71** and, in accordance with the invention, should not significantly exceed about 20 percent of the length of the covering tube **71**. Most advantageously, the adhesive area **72** is symmetrically related with respect to the length of the roll **70** and its covering tube **71**.

By limiting the extent of the adhesively bonded area **72** to narrow central regions of the roll and tubing, a certain amount of desirable relative movement is accommodated between the tubing **71** and the underlying roll **70**, which is advantageous because of the flexing of the roll and its covering during operation.

It should be understood that the specific forms of the invention herein illustrated and described are intended to be representative only, as certain changes may be made therein without departing from the clear teachings of the disclosure. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

We claim:

1. The method of covering a roll with a covering of thermoplastic material and of the type comprising (i) an elongated cylindrical body portion arranged and intended for disposition over the cylindrical outer surface of the roll to be covered, (ii) said body portion being initially set in radially distended condition to have an internal diameter slightly greater than the external diameter of said roll, and being heat-shrinkable toward a diameter less than that of the roll, (iii) one end of said roll covering being open at a diameter at least equal to that of the roll, to accommodate endwise application of the covering over the roll, and (iv) an integral necked-down section at the opposite end of said covering, (v) said necked-down section having an initially set internal diameter less than the diameter of the roll to be covered, to provide a positioning surface for holding and concentrically locating said covering relative to the roll to be covered, during installation, which method comprises,

(a) applying the necked-down covering end-wise over the roll to be covered,

(b) gripping and applying axial tension to the open end of the covering to seat the necked-down section firmly against the end of the roll and thereby concentrically positioning the covering relative to the roll in the region of the necked-down end of the covering, and

(c) applying localized heat to the covering to shrink the body portion thereof into snug fitting relation with the roll, progressively from the necked-down end toward the open end of the tube, whereby to maintain substantial concentricity between the covering and the roll in the region of the applied heat.

2. The method of covering a large diameter, horizontally disposed roller or the like with a heat-shrinkable film material, which comprises

(a) positioning a tube of the film over said roller,

(b) said tube being semi-permanently stretched from an initial diameter less than the diameter of said roller to a diameter greater than the roller, and being of a length to project beyond at least one end of the roller,

(c) shrinking the projecting end of said tube into uniformly snug relation to said roller, by applying heat locally to said projecting end to thereby con-

centrically position the tube relative to the roller in the region of the projecting end of the tube, and

(d) thereafter applying localized heat progressively along said tube toward the opposite end thereof, to progressively shrink the tube onto said roller, whereby to maintain substantial concentricity between the tube and the roller in the region of the applied heat.

3. The method of claim 2, further characterized by

(a) said tube being maintained under axial tension while said heat is applied progressively along said tube.

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U.S. Cl. X.R.

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