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Arvidson, Jr.

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[54] **FLAT PHOTOGRAPHIC SHEETS PRODUCED BY FORWARD AND REVERSE REWINDING OF PHOTOGRAPHIC MATERIAL**

[76] Inventor: **Harold Carl Arvidson, Jr.**, 3 Monterey Dr., Princeton Junction, N.J. 08550

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[51] **Int. Cl.** **B29c 17/14,** B29c 17/02

[58] **Field of Search** 264/160, 157, 285, 235, 264/346; 162/197, 270, 271; 242/55, 75.2

[56] **References Cited**

UNITED STATES PATENTS

3,479,426	11/1969	De Smedt	264/345
3,030,173	4/1962	Kurzke et al.	264/210
2,293,178	8/1942	Stocker	264/160
1,807,274	5/1931	Beidler	242/75.45
2,658,432	11/1953	Baumgartner	162/262
1,560,670	11/1925	De Vries	162/271

FOREIGN PATENTS OR APPLICATIONS

332,094	5/1903	France	162/270

Primary Examiner—Robert F. White
Assistant Examiner—James B. Lowe

[57] **ABSTRACT**

A process for producing flat sheets, particularly photographic sheets for use in automatic film changing equipment, from a stored roll of material. The process is characterized by rewinding the inner convolutions of the stored roll, which have the highest degree of curl, in a manner that they again become the inner convolutions of roll material, i.e., by rewinding with the direction of roll-set curl and then reverse rewinding against the direction of roll-set curl.

16 Claims, 8 Drawing Figures

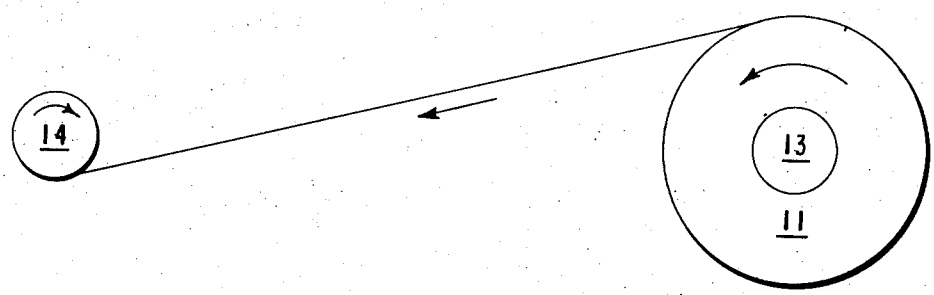


FIG. 1

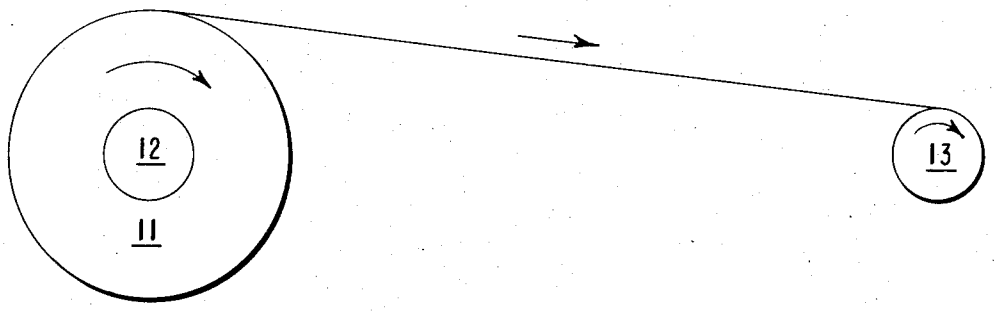


FIG. 2

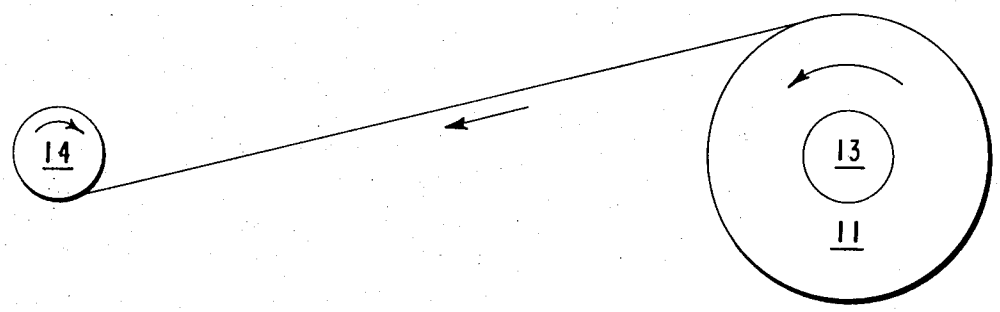


FIG. 3A

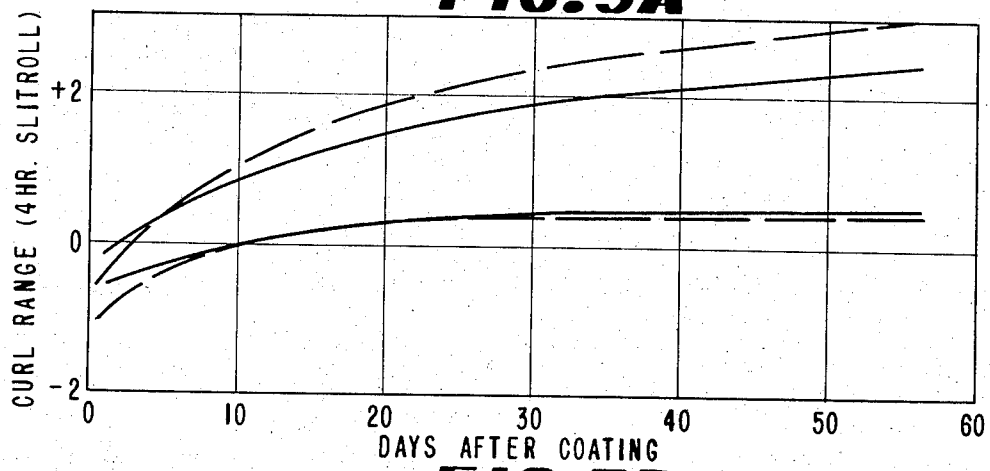


FIG. 3B

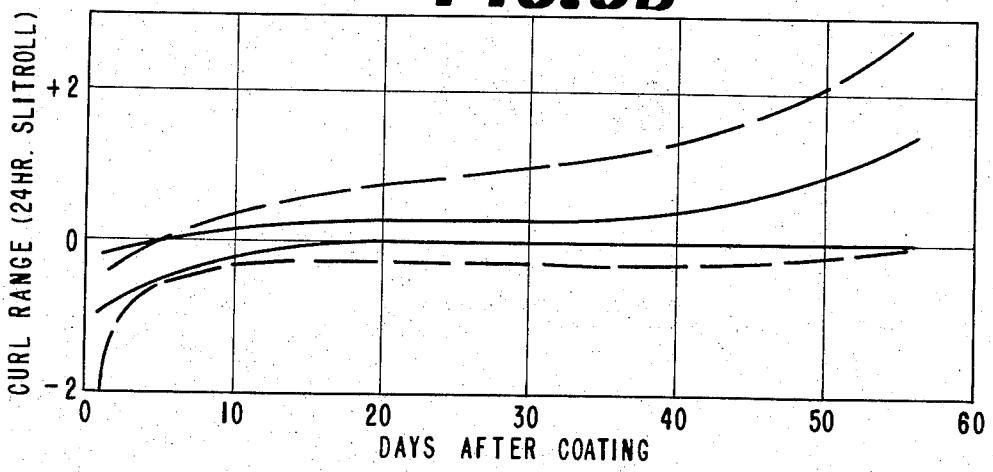


FIG. 3C

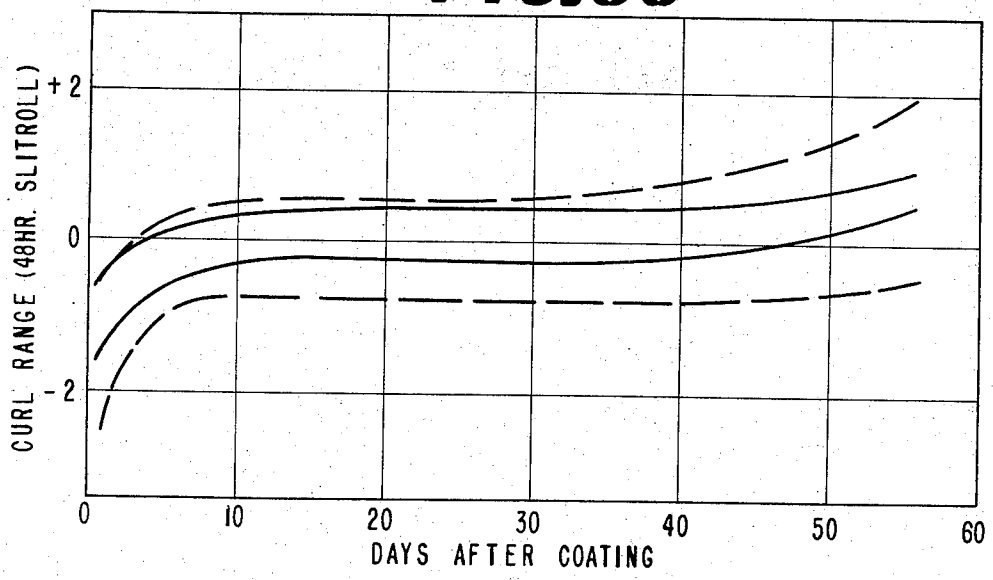


FIG. 4A

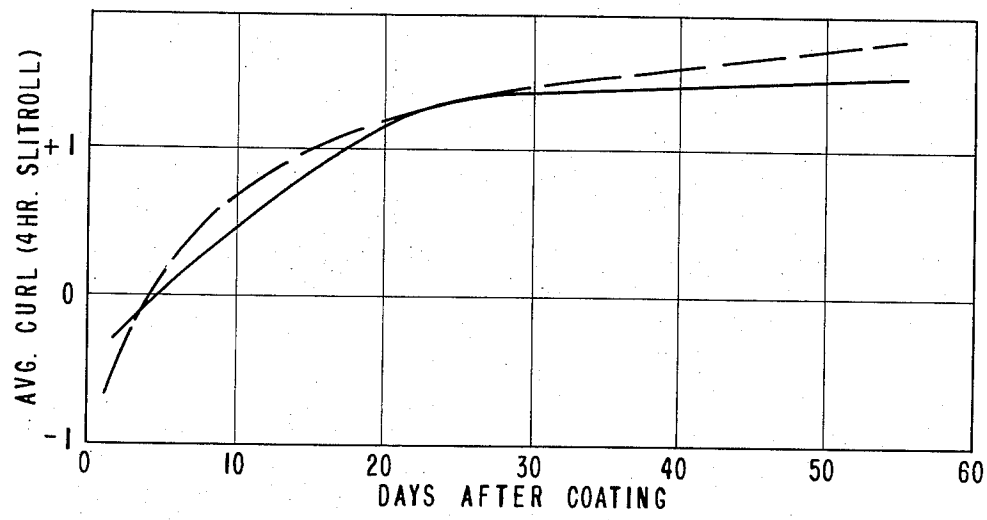


FIG. 4B

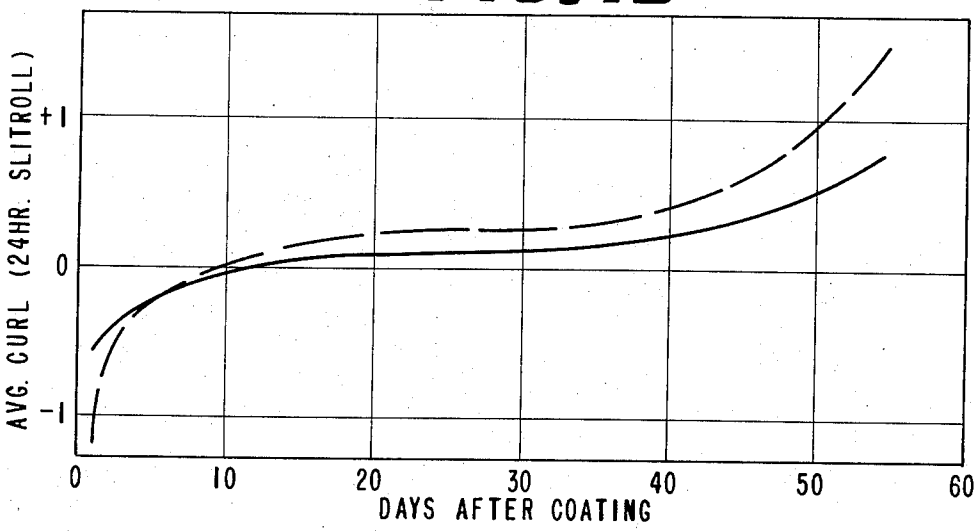
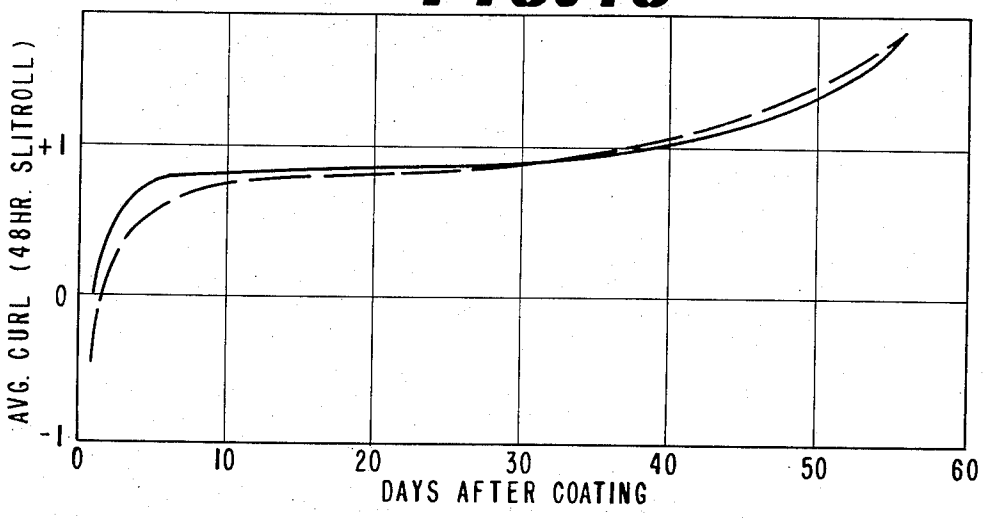


FIG. 4C



FLAT PHOTOGRAPHIC SHEETS PRODUCED BY FORWARD AND REVERSE REWINDING OF PHOTOGRAPHIC MATERIAL

BACKGROUND OF THE INVENTION

Field of the Invention: This invention relates to a process for removing curl from films, particularly photographic films. Still more particularly it relates to a process for removing curl from medical and industrial x-ray films used in automatic film changing apparatus.

Description of the Prior Art: Processes and apparatus for eliminating curl from webs are well known in the web handling art.

U.S. Pat. No. 2,658,432 teaches the use of a device for decurling paper webs having spaced ironers and a roll over which the web is looped to bring the web into contact with said ironers and cancel roll-set curl in the web as it passes over said ironers. The device of this patent uses tensioning rolls to increase the decurling action proportional to the curl of the paper close to the web core.

U.S. Pat. No. 1,807,274 teaches the use of a device for removing the curl of a photographic paper film. This device uses a roller to engage the film unwound from the original roll, and increases the tensioning action of the roller proportional to the curling action of the film, as it is taken from the roll near the core.

SUMMARY OF THE INVENTION

A process for removing the curl from a stored roll of material, comprising:

a. rewinding a roll of material in the direction of roll-set curl,

b. reverse rewinding the material against the direction of roll-set curl, and

c. holding the reverse rewound material for a period of time sufficient to cancel the roll-set curl.

Steps (a) and (b) can be carried out in reverse order with the same result.

The process is characterized by the fact that the inner convolutions of the stored roll, which have the highest degree of curl become the inner convolutions of the rewound and reverse rewound roll; and the roll-set curl is canceled in proportion to the degree of said curl throughout the roll.

The present invention has been found to be particularly effective in canceling roll-set curl in rolls of photographic material, particularly those formed from the polyesterification product of a dicarboxylic acid and a dihydric alcohol made according to the teachings of Alles, U.S. Pat. No. 2,779,684, and the patents referred to in the specification of that patent. The process is most effective on uncoated films or films that have been coated on both sides, and least effective on films coated on only one side.

The advent of automatic film changing equipment in recent years has created more stringent requirements for production of flat sheets of medical and industrial x-ray films. The process is particularly useful as the first step in a process for converting photographic material, particularly medical and industrial x-ray films into flat sheets.

The advantages of the present invention are that it obviates the need for expensive apparatus for eliminating roll-set curl, and that it can be carried out on unwind and rewind machines in conjunction with slitting operations, all of which are well known in the web handling and photographic material handling arts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing illustrating the rewinding of a roll of photographic material in the direction of roll-set curl.

FIG. 2 is a schematic drawing illustrating reverse rewinding of the rewound roll of photographic material of FIG. 1 against the direction of roll-set curl.

FIGS. 3(*a*), 3(*b*) and 3(*c*) are graphical comparisons of the range of curl present in sheets of film prepared from a roll of photographic material processed in accordance with the subject invention and the range of curl present in sheets of film prepared from a roll of photographic material which has merely been rewound against the direction of roll-set curl.

FIGS. 4(*a*), 4(*b*) and 4(*c*) are graphical comparisons of the average curl in sheets of film prepared from a stored roll of photographic material processed in accordance with the subject invention and the average curl in sheets of film prepared from a stored roll of photographic material which has merely been rewound against the direction of roll-set curl.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Curl in finished sheets of industrial and medical x-ray films can be substantially attributed to the storage of photographic material in rolls. When photographic material which has been stored in rolls, between coating of emulsion and anti-abrasion layers, and converting into sheets, i.e., by slitting and chopping, the finished sheets retain a degree of curl directly attributable to the fact that they have been stored in rolls. This curl can be designated as "roll-set curl" and is caused by tension and compression of the outer and inner surfaces of photographic material when the material is wound and stored in rolls. The tension and compression of the outer and inner surfaces, respectively, causes elongation and contraction of the surfaces, particularly when the material consists of a substrate coated on both sides with some coating material and when the film is unwound, although the stresses are removed from the surfaces, these surfaces do not immediately recover their original length. This problem may be accentuated by hardening of the emulsion and anti-abrasion layers during roll storage. Other factors which contribute to roll-set curl are the ambient storage conditions, and the diameter of the mandrel on which the roll material is stored.

Roll-set curl can be effectively reduced by the process of the present invention. The first step in the process, illustrated in FIG. 1, is to rewind a roll of material stored on a mandrel 12 onto a second mandrel 13, of approximately the same dimension. The rewinding takes place as illustrated in the direction of the roll-set curl. The second step, illustrated in FIG. 2, is to reverse rewind the roll of material, which is now on mandrel 13, onto mandrel 12 or a third mandrel 14. The reverse rewinding takes place as illustrated, against the direction of roll-set curl. The next step is to hold the reverse rewound material on mandrel 14 for a time sufficient to cancel the roll-set curl. Finally the roll can be slit and chopped into individual film sheets. If desired, steps one and two can be reversed.

Although the process has been found to be particularly useful for producing flat sheets of medical and industrial x-ray film from photographic material having coated layers on both sides of a film support formed from the polyesterifacation product of a dicarboxylic acid and a dihydric alcohol made according to the teaching of U.S. Pat. No. 2,779,684, it is also useful where the supports are the polyethylene terephthalate/isophthalates of British Pat. No. 766,290 and Canadian Pat. No. 562,672 and those obtainable by condensing terephthalic acid and dimethyl terephthalate with propylene glycol or cyclohexane 1,4-dimethanol (hexahydro-p-xylene alcohol). The above polyester films tend to take on a permanent set when stored in rolls due to their high stress decay and low tensile recovery. The emulsion layers on both sides of the support add to the permanent set and due to their hardening operate against the elastic recovery of the finished sheets of film, if the roll material is stored for an extended period of time subsequent to coating and previous to converting into sheets. The above effects are accentuated when the roll material is stored at temperatures above 25° C. and 75 percent relative humidity. The degree of roll-set curl is also effected by the diameter of the mandrel on which the roll material is stored.

The preferred hold times of the rewound and reverse rewound roll material before chopping into sheets varjes with the length of time the roll material has been stored subsequent to coating the material, and are set forth below:

Storage Time	Hold Time
1–7 days	2–18 hrs.
7–35 days	12–48 hrs.
>35 days	24–72 hrs.

The preferred hold times set forth above are specifically correlated with roll material stored on a 6-inch diameter mandrel and ambient storage conditions of 25° C. and 50 percent RH.

Variation from the preferred hold times recited above are contemplated when changes of ambient conditions or mandrel size is employed. In addition the process may also be used when the photographic support material has been stored for an extended period of time previous to coating with the emulsion and antiabrasion layers.

Although the process of the invention has no significant detrimental effect on the photographic properties of the film, it is imperative that winding and rewinding be conducted in a dust and dirt free environment to prevent damage to the film surface and quality defects in the finished sheets.

Although the process is exemplified by specific reference to film support thickness, coating weights, mandrel diameter and ambient conditions, substantial variations of these and other parameters are contemplated and within the scope of the invention.

Curl in an x-ray film causes the finished sheets of film to assume a shape resembling a portion of an approximately cylindrical surface. The magnitude of the curl is measured by assuming that the surface is a portion of a right circular cylinder, and by determining the radius of curvature of this cylinder in meters. The reciprocal of this radius of curvature (in meters) is the magnitude of the curl in diopters. The term diopter comes from geometrical optics, where it is the unit given to the reciprocal of the focal length of a lens in meters.

To evaluate the effectiveness of the process of this invention in reducing curl, a standardized measurement procedure was established. First, 7 × 7 inch square samples were taken from the center of 14 × 17 inch finished sheets of x-ray film. These sample sheets were then suspended with the curl axis vertical, to eliminate any gravitational effects, and equilibrated for an hour at 25° C. and 50–60 percent relative humidity.

To maintain uniformity and minimize measuring error, two methods of measuring curl were adopted. The first method comprises matching the curve of the film with the curve of an adjustable radius "Acu-Arc" ruler. The radius in inches was read off the ruler's scale and converted to diopters by dividing the radius into 39.37 inch/meter. The second method comprises measuring the perpendicular distance between a chord connecting the ends of the arc formed by the film and the midpoint of the arc with a micrometer. The radius of curvature was then determined from the relationship:

$$r = x/(1 - \cos \theta/2)$$

where,

x = the perpendicular distance between the midpoint of the arc formed by the film and the chord connecting the ends of the arc, and

$$\theta = 360° \, a/2 \, \pi \, r$$

where,

a = the arc length.

The value of r can be computed for each circumstance, or, for convenience, a table can be established for converting values of x to diopter values at specific arc lengths, i.e., 7 inches. For an arc length of 7 inches, a value of X = 0.161 corresponds to a diopter value of 1.036.

The effectiveness of the present invention will now be described in the following examples, from which it will be apparent that the process of the invention produces sheets of a substantially uniform degree of curl within the preferred range of 0 ± 1 diopters, where for some reason the coated stock cannot be slit and chopped into sheets within 1 day of when it is coated.

EXAMPLE 1

A high speed medical x-ray film was prepared having both a gelatino-silver iodobromide emulsion layer and an anti-abrasion layer coated on both sides of a 0.007 inch thick polyethylene terephthalate film support. The emulsion layer had a coating weight of 78 to 80 milligrams of silver bromide per square decimeter (78 mg/dm² to 80 mg/dm²), and the anti-abrasion layer had a coating weight of 8–10 milligrams of gelatin per square decimeter (8 mg/dm² to 10 mg/dm²). The polyethylene terephthalate film support was prepared by coating a copolymer subbing layer of vinylidene chloride, ethyl acrylate and itaconic acid as taught in Example IV of assignee's patent to Alles U.S. Pat. No. 2,627,088. The film was prepared in the conventional manner and was wound on a 6-inch diameter mandrel and stored for up to 60 days at 25° C. and 50 percent relative humidity. The rolls were 3,300 feet long.

To illustrate the magnitude of the problem, one roll of this material, which had been stored for 2 days, was slit into three equal widths and rewound on 6-inch di-

ameter mandrels, against the direction of stored roll-set curl. This is the conventional method of removing curl from roll stock. The three slit rolls were chopped into sheets, one 4 hours after slitting, one after 24 hours of storage, and one after 48 hours of storage at the same temperature and humidity as above. The sheets were sampled and curl measured as set forth above. The curl range throughout the rolls (for 4 hours, 24 hours and 48 hours slit stock holding time, respectively) was +1 to 0 diopters, −1 to −2.5 diopters, and −1.0 to −2.75 diopters. While the degree of curl and range of curl was within a preferred range of 0 ± 1 diopter when the roll was immediately chopped into sheets, it is apparent that the degree and range of curl was outside the preferred range for the rolls stored for more than one day following the slitting operation.

The entire procedure of slitting, rewinding and chopping can be repeated on rolls stored up to 60 days after coating, with the results shown by the dotted lines on FIGS. 3 and 4.

To illustrate the effectiveness of the present invention, rolls of the above material can be removed from storage at various times up to 60 days after coating, slit into three equal rolls. Instead of merely reverse rewinding the rolls, however, these sheets should be first rewound in the direction of roll-set curl and then reverse rewound against the direction of roll-set curl according to the process of the present invention. The three rolls can then be chopped into sheets; one after 4 hours of storage, one after 24 hours of storage and one after 48 hours of storage. The sheets can then be sampled and curl measured as set forth above with the results illustrated as the solid lines on FIGS. 3 and 4.

FIGS. 3(*a*), 3(*b*) and 3(*c*) graphically compare the range of curl in sheets produced using the process of the present invention and sheets produced by the conventional method of rewinding against the direction of roll-set curl, as a function of wide stock roll storage time after coating for the three slit stock roll hold times.

FIGS. 4(*a*), 4(*b*) and 4(*c*) graphically compare the average degree of curl in sheets produced using the process of the invention and sheets produced by the conventional method of rewinding against the direction of roll-set curl, as a function of wide stock roll storage time after coating for the three slit stock roll hold times.

EXAMPLE 2

Two rolls of medical x-ray film, A and B, were prepared and slit as recited above, however, the second roll was rewound and reverse according to the process of the present invention. The two rolls had been stored for four days previous to rewinding and slitting steps. The degree of curl and curl range through the rolls when the slit rolls were held and respectively chopped into sheets is set forth below:

	A	B
	Reverse Rewound	Rewound and Reverse Rewound
0 day	2.5 to 0 diopters	2.5 to 0 diopters
½ day	0 to −1.0 diopters	−0.5 to 0 diopters
1 day	0 to −1.0 diopters	−1.0 to 0 diopters

The rewound and reverse rewound roll B produced sheets of a substantially more uniform range of curl within the preferred range of 0 ± 1 diopter when chopped into sheets after being held before chopping for 1/2 day.

EXAMPLE 3

Two rolls of medical x-ray film, C and D, were prepared as recited in Example 2 and stored for 7 days previous to rewinding and slitting steps. The degree of curl and curl range when the slit rolls were held and respectively chopped into sheets is set forth below:

	C	D
	Reverse Rewound	Rewound and Reverse Rewound
0 day	3.0 to 1.0 diopters	3.0 to 1.0 diopters
1 day	0.0 to −1.0 diopters	−0.5 to −0.5 diopters
2 days	−0.5 to −2.0 diopters	−0.5 to −0.5 diopters

The rewound and reverse rewound roll D produced sheets of a substantially more uniform range of curl within the preferred range of 0 ± 1 diopter after having been held before chopping for 1 or 2 days.

EXAMPLE 4

Two rolls of medical x-ray film, E and F, were prepared as recited in Example 2 and stored for 14 days previous to the rewinding and slitting steps. The degree of curl and curl range when the slit rolls were respectively chopped into sheets is set forth below:

	E	F
	Reverse Rewound	Rewound and Reverse Rewound
0 day	3.0 to 1.0 diopters	3.0 to 1.0 diopters
1 day	0.0 to −1.0 diopters	−0.5 to −0.5 diopters
2 days	−0.5 to −2.0 diopters	−0.5 to −0.5 diopters

The rewound and reverse rewound roll F produced sheets of a substantially more uniform range of curl within the preferred range of 0 ± 1 diopter after having been held for 1 or 2 days.

Two rolls of medical x-ray film, G and H, were prepared as recited in Example 2 and stored for 35 days previous to rewinding and slitting steps. The degree of curl and curl range when the slit rolls were respectively chopped into sheets is set forth below:

	G	H
	Reverse Rewound	Rewound and Reverse Rewound
0 day	4.0 to 1.0 diopter	4.0 to 1.0 diopter
1 day	1.5 to −0.5 diopter	0.5 to 0 diopters
2 days	1.0 to −1.0 diopters	0 to 0 diopters

The rewound and reverse rewound roll H produced sheets of a substantially more uniform range of curl within the preferred range of 0 ± 1 diopter after having been held before chopping for 1 or 2 days.

What is claimed is:

1. A process for removing the roll-set curl from a stored roll of material comprising the steps of

a. rewinding said material in the direction of roll-set curl;
b. reverse rewinding said material against the direction of roll-set curl; and
c. holding the reverse rewound material for a time sufficient to cancel the roll-set curl.

2. The process of claim **1** wherein said material has coated layers on both sides which contribute to the roll-set curl.

3. A process for producing flat smaller discrete sheets from a stored roll of material comprising the steps of:

a. rewinding said material in the direction of roll-set curl;
b. reverse rewinding said material against the direction of roll-set curl;
c. holding the reverse rewound material for a time sufficient to cancel the roll-set curl; and
d. converting said material into smaller discrete sheets.

4. The process of claim **3** wherein said material has coated layers on both sides which contribute to the roll-set curl.

5. The process of claim **3** wherein said material is photographic material and the step of holding the reverse rewound material extends to up to 72 hours.

6. The process of claim **4** wherein said photographic material comprises coated layers on both sides of a polyester film support.

7. The process of claim **3** wherein said material is medical and industrial x-ray film and the step of holding the reverse rewound material extends for up to 72 hours.

8. The process of claim **3** wherein the step of converting said material into smaller discrete sheets is accomplished by first slitting rolls of the material into narrower rolls and then chopping the material into smaller discrete sheets.

9. A process for removing the roll-set curl from a stored roll of material comprising the steps of

a. reverse rewinding said material against the direction of roll-set curl;
b. rewinding said material in the direction of roll-set curl; and
c. holding the reverse rewound material for a time sufficient to cancel the roll-set curl.

10. The process of claim **9** wherein said material has coated layers on both sides which contribute to the roll-set curl.

11. A process for producing flat smaller discrete sheets from a stored roll of material comprising the steps of:

a. reverse rewinding said material against the direction of roll-set curl;
b. rewinding said material in the direction of roll-set curl;
c. holding the reverse rewound material for a time sufficient to cancel the roll-set curl; and
d. converting said material into smaller discrete sheets.

12. The process of claim **11** wherein said material has coated layers on both sides which contribute to the roll-set curl.

13. The process of claim **11** wherein said material is photographic material and the step of holding the reverse rewound material extends to up to 72 hours.

14. The process of claim **12** wherein said photographic material comprises coated layers on both sides of a polyester film support.

15. The process of claim **11** wherein said material is medical and industrial x-ray film and the step of holding the reverse rewound material extends for up to 72 hours.

16. The process of claim **11** wherein the step of converting said material into smaller discrete sheets is accomplished by first slitting rolls of the material into narrower rolls and then chopping the material into smaller discrete sheets.

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