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Leisring

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[54] **ENDLESS BAND WINDING APPARATUS**

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[51] **Int. Cl.** **B65h 17/48**

[58] **Field of Search** ..... 242/55.19 R, 55.19, 55, 68.7, 242/78.7; 352/128

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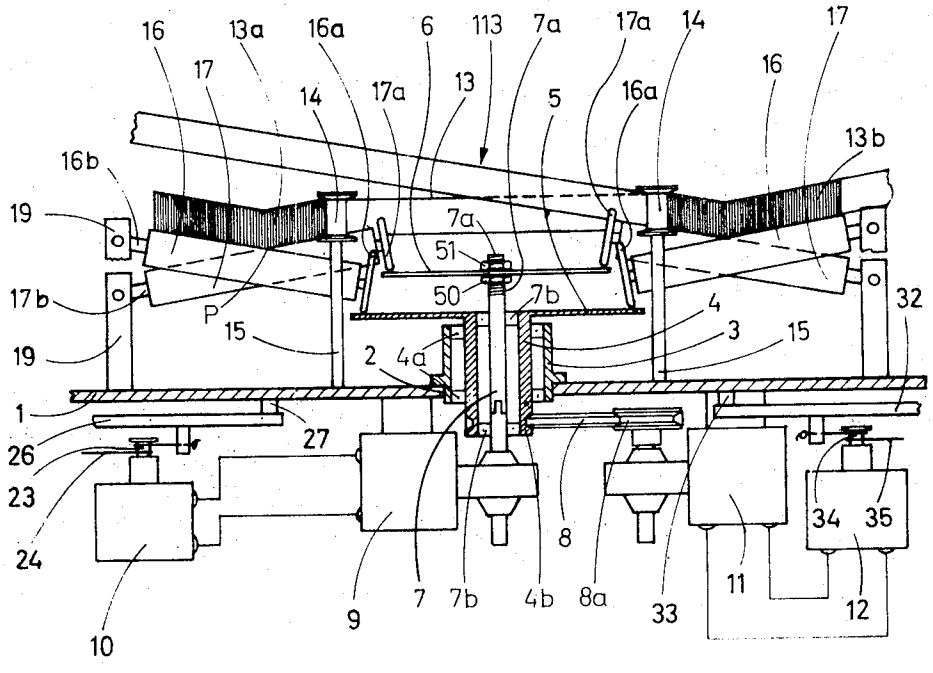
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[57] **ABSTRACT**

Apparatus for simultaneous convoluting and unwinding of endless motion picture film the major part of which is convoluted to form a roll and an unconvoluted part of which is transported step-by-step through a motion picture projector has two sets of alternating driving rollers which extend radially of and support the roll of convoluted film from below so that the axis of the roll is vertical. The rollers of one set support the outer annular section of the roll and are inclined downwardly toward the axis of the roll. The rollers of the other set support the inner annular section of the roll and are inclined outwardly and downwardly away from the axis of the roll. Each set of rollers is driven by a separate variable-speed electric motor through the intermediary of a horizontal turntable in such direction that the outer section of the roll collects and the inner section of the roll pays out the film. The speed of the motor which drives the one set of rollers is adjustable by a first detector which detects the changes in tension of that portion of the film which is being convoluted on the outer section, and the speed of the motor which drives the other set of rollers is adjustable by a second detector which detects the changes in tension of that portion of the film which is being withdrawn from the inner section of the roll. At least one of the turntables is movable between several levels to thereby change the inclination of the respective set of rollers and to thus enable the apparatus to support and rotate rolls of different outer diameters.

14 Claims, 2 Drawing Figures

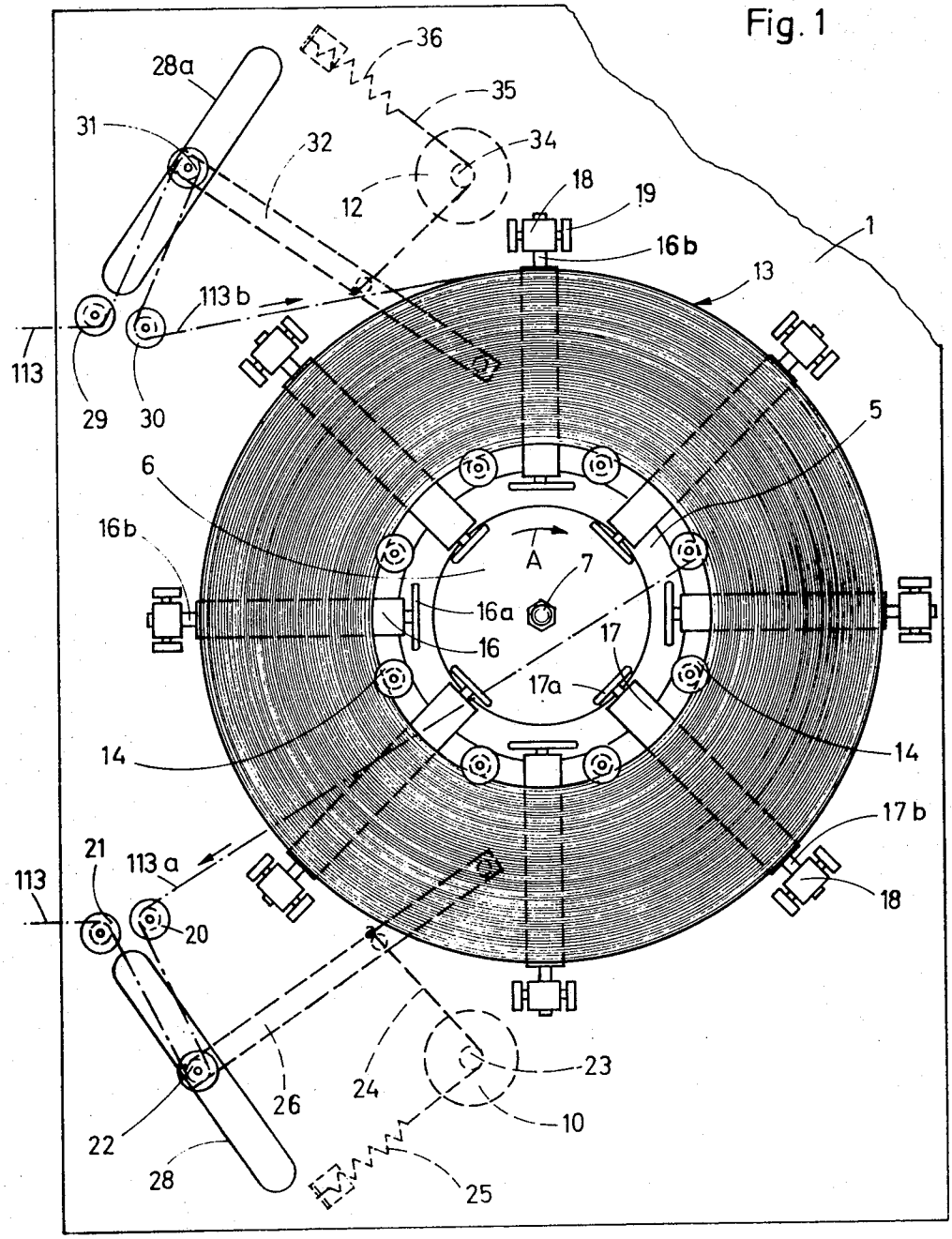


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SHEET 1 OF 2

Fig. 1



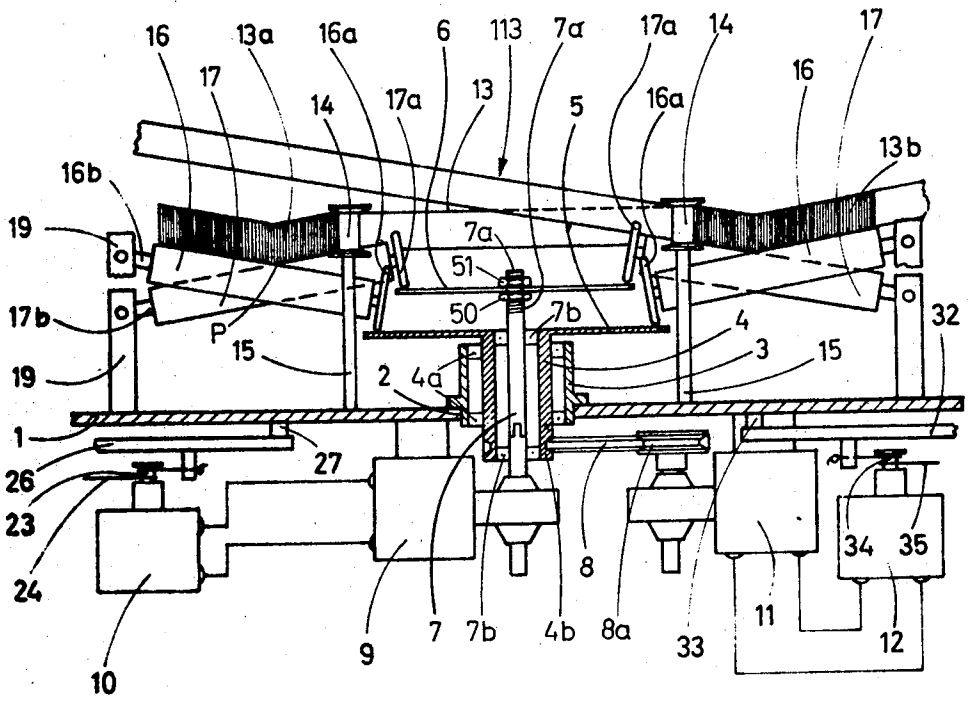
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Fig. 2



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ENDLESS BAND WINDING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for supporting and rotating rolls of convoluted band material or the like, and more particularly to improvements in apparatus for supporting and rotating rolls of the type which constitute substantial or major parts of endless bands, particularly endless photographic films.

It is known to store an endless band of photographic film, particularly motion picture film, in such a way that a substantial or major portion of the film forms a roll whereby the film is normally withdrawn from the interior of the roll and is being convoluted onto the outer annular section of the roll. The withdrawn length of the film can be cased to pass through a cinematographic apparatus for projection of the images of its frames onto a screen or the like. The roll of convoluted film rests on driven rollers which extend radially of the roll and rotate the latter at a speed which corresponds to the desired speed of film transport through the cinematographic apparatus.

A drawback of presently known apparatus of the just outlined character is that the driving torque which is transmitted to the innermost convolutions of a film roll propagates itself by friction between adjoining convolutions toward the outer most convolution which are thereby rotated at an excessive speed to unduly increase the tension in that portion of the film which is being returned to the roll. Attempts to reduce such undue tensioning of returning film include the provision of conical supporting and driving rollers which taper toward the periphery of the roll so that the peripheral speed of the conical rollers decreases in a direction from the innermost toward the outermost convolution of the roll. Such conical rollers thus oppose the tendency of outermost convolutions to rotate at a speed which would cause undue tensioning of the returning film. It was found that the improvements which can be achieved with conical rollers are insufficient to insure proper withdrawal of film from and proper winding of film onto the thus mounted and driven roll. This is attributable to the fact that the magnitude of aforementioned friction between adjoining convolutions of the roll depends on the friction coefficient of the film as well as on the tautness of convolutions which form the roll. These two factors vary from roll to roll so that the provision of conical rollers cannot invariably insure proper withdrawal and much less proper rewinding of film onto the roll without excessive tensioning. Experiments with conical rollers have shown that such rollers are reasonably satisfactory for use only in connection with relatively small rolls of film, i.e., with rolls wherein the difference between the inner and outer diameters is relatively small.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an apparatus for simultaneous convoluting and unwinding of endless bands or the like in such a way that excessive tensioning of the band in the outermost convolutions of the roll which forms a substantial or major part of the band can be controlled with a high degree of accuracy irrespective of the length of band which is convoluted to form the roll.

Another object of the invention is to provide an apparatus wherein the rate of unwinding from and/or the rate of convoluting of an endless band onto a roll can be regulated automatically in dependency on the required speed of transport of that length of the band which is not convoluted on the roll.

A further object of the invention is to provide the apparatus with novel means for supporting and driving the convoluted part of an endless band.

An additional object of the invention is to provide the apparatus with novel means for detecting the changes in tension of that portion of the band which is being withdrawn from the roll and/or for detecting the changes in tension of that portion of the band which is being convoluted onto the roll.

The invention is embodied in an apparatus for simultaneous convoluting and unwinding of an endless band, such as motion picture film which is transported through a motion picture camera or projector, a substantial length of which forms a roll having a plurality of convolutions including an innermost and an outermost convolution, a first portion of which is integral with the innermost convolution, and a second portion of which is integral with the outermost convolution as well as with the first band portion. The apparatus comprises two sets or groups of driving rollers which extend substantially radially of and support the roll from below, mounting means rotatably supporting the rollers in such positions that one of the group of rollers supports a first annular section of the roll which includes the outermost convolution and that the other group of rollers supports a second annular section of the roll which includes the innermost convolution, and first and second variable-speed drive means for respectively rotating the first and second groups of rollers independently of each other whereby the rollers rotate the roll in a predetermined direction with attendant withdrawal of one of the band portions and convoluting of the other band portion.

The apparatus preferably further comprises first and second adjusting means each of which is associated with a different drive means to change the speed of the respective drive means. In accordance with a feature of the invention, the first and second adjusting means are arranged to change the speed of the associated drive means in response to changes in the tension of the first and second band portions.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved apparatus itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view of an apparatus which embodies the invention; and

FIG. 2 is a partly elevational and partly central vertical sectional view of the apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The apparatus which is shown in FIGS. 1 and 2 serves for simultaneous collection or convoluting and unwinding or paying out of an endless web or band 113 a major or substantial portion of which is in convoluted condition to form a roll 13. The band 113 may be an exposed and developed photographic film of the type which is suited for use in cinematographic apparatus and is assumed to be ready for transport through a motion picture projector (not shown) so that the images of successive film frames are projected onto a screen or the like. Such endless bands or webs of photographic film can be used for commercial or educational purposes, for example, to project a series of images representing advertising matter or a series of images to a class of students.

The apparatus comprises a rectangular plate-like support 1 which is mounted in a substantially horizontal plane and is provided with a centrally located circular opening 2 (FIG. 2). The lower end portion of an upright cylindrical bearing sleeve 3 is received in the opening 2 and is secured to the support 1; this sleeve serves to rotatably support a hollow drive shaft 4 which is mounted in antifriction bearings 4*a* and the upper end portion of which extends beyond the bearing sleeve 3 and is rigidly or adjustably and separably connected with a horizontal disk-shaped turntable or platform 5. The lower end portion of the hollow shaft 4 extends beyond the lower end of the bearing sleeve 3 and constitutes or is provided with a pulley or sheave 4b for an endless V-belt 8.

A second horizontal disk-shaped turntable or platform 6 of a smaller diameter is mounted at a level above the turntable 5 and is adjustably secured to the upper end portion of a drive shaft 7 which is rotatable in antifriction bearings 7*b* provided therefor in the hollow shaft 4. The lower end portion of the shaft 7 extends beyond the pulley 4*b* and is driven by a variable-speed electric motor 9 which is mounted at the underside of the support 1. A second variable-speed electric motor 11, also mounted at the underside of the support 1, drives the V-belt 8 through the intermediary of a pulley 8*a*. The RPM of the output shaft of the motor 11, and hence the rotational speed of the lower turntable 5, can be regulated by an adjusting device including a potentiometer 12 having a rotary sliding contact. A similar potentiometer 10 is provided to regulate the RPM of the motor 9, i.e., the rotational speed of the upper turntable 6. The parts 4, 8, 11 and 7, 9 respectively serve to rotate the turntables 5, 6 at a plurality of speeds but in the same direction (counter to the direction indicated by the arrow A shown in FIG. 1).

The turntables 5, 6 respectively serve to transmit torque to first and second groups or sets of elongated driving rollers 16, 17 which support the roll 13 of the band 113 from below and cause the roll 13 to rotate clockwise (arrow A in FIG. 1) due to frictional engagement between the peripheral surfaces of the driving rollers 16, 17 and the lower edge faces of convolutions which form the roll 13. As shown in FIG. 1, a first portion 113*a* of the band 113 is being withdrawn from the interior of the roll 13 (this band portion 113*a* is integral with the innermost convolution of the roll 13) and a second portion 113*b* of the band 113 is being convoluted around the roll. The non-convoluted length of the band 113 forms a loop successive increments of which are transported through the motion picture projector. The innermost convolution of the roll 13 is trained over guide rollers 14 which are rotatable on vertical shafts 15 mounted on the support 1. The band portion 113*b* is integral with the band portion 113*a* and with the outermost convolution of the roll 13.

The driving rollers 16, 17 extend radially of the roll 13 and their inner end portions are respectively provided with or constitute friction wheels 16*a*, 17*a* which are respectively held in frictional engagement with and receive torque from the upper surfaces of the turntables 5 and 6. As shown in FIG. 1, the driving rollers 16 and 17 are respectively equidistant from each other and the rollers 16 alternate with the rollers 17, as viewed in the circumferential direction of the roll 13. In the illustrated embodiment, the roll 13 is supported and rotated by four rollers 16 and by four rollers 17.

The driving rollers 16 and 17 are supported by mounting means including shafts 16*b*, 17*b* which extend outwardly beyond the respective driving rollers and are pivotable in upright bearing or mounting members 19 which are installed on the support 1. Each bearing member 19 has a bifurcated upper end portion whose prongs flank a block 18 which is turnable about a horizontal axis extending substantially tangentially of the roll 13. The shafts 16*b* and 17*b* are mounted in the respective blocks 18 so that each such shaft can pivot in a vertical plane which includes the axis of the roll 13. The height of those bearing or mounting members 19 which carry the shafts 16*b* for the driving rollers 16 is such that the shafts 16*b* are located at a level above the friction wheels 16*a*, i.e., the axes of the rollers 16 are inclined downwardly toward the axis of the roll 13. The bearing members 19 for the blocks 18 which carry the shafts 17*b* for the driving rollers 17 are shorter so that the shafts 17*b* are located at a level below the friction wheels 17*a*, i.e., the axis of each driving roller 17 is inclined downwardly and outwardly away from the axis of the roll 13. When looked at in a horizontal direction (see FIG. 2), the axes of two adjoining driving rollers 16, 17 cross each other substantially midway between the axial ends of such rollers and the lines along which the peripheral surfaces of the driving rollers 16 are contacted by the convolutions of the outer annular section 13*b* of the roll 13 make with the lines along which the peripheral surfaces of the driving rollers 17 are contacted by the convolutions of the inner annular section 13*a* of the roll 13 an obtuse angle alpha. In other words, the driving rollers 16, 17 can be said to form a rather shallow V-shaped receptacle for the roll 13 whereby the inner and outer annular sections 13*a*, 13*b* of the roll respectively rest on the rollers 16 and 17.

When the rollers 16 and 17 are respectively driven by the motors 11, 9 through the intermediary of the turntables 5 and 6, the friction between the peripheral surfaces of the rollers 16, 17 and the portions 13*b*, 13*a* causes the roll 13 to rotate in a clockwise direction. The band portion 113*a* is being withdrawn from the interior of the roll 13 and is caused to travel around a first stationary guide roller 20, a movable guide roller 22, a second stationary guide roller 21 and thereupon enters the motion picture projector. The projector comprises its own band transporting mechanism, such as a con-

ventional claw pull-down, which advances the band 113 stepwise at a constant rate so as to place successive film frames into register with the film gate.

In order to conform the speed of withdrawal of innermost convolutions of the roll 13 to the speed at which the band 113 is transported through the motion picture projector, the speed of the motor 9 which rotates the driving rollers 17 for the inner annular section 13*a* can be regulated independently of the speed of convolutions which form the annular section 13*b*. The speed of the motor 9 is regulated automatically by a detector which scans the tension of the band portion 113*a* on its way to the projector and controls the aforementioned potentiometer 10. The shaft 23 for the sliding contact of the potentiometer 10 serves as a sheave for an intermediate portion of a cable or cord 24 one end of which is connected with the intermediate portion of a one-armed lever 26 and the other end of which is connected with a helical spring 25. The spring 25 is anchored in the support 1 and the lever 26 is pivotable on a pin 27 which extends from the underside of the support 1. The free end of the lever 26 carries the aforementioned guide roller 22 for that portion 113*a* of the band 113 which is about to enter the projector. The shaft of the guide roller 22 extends through an elongated slot 28 of the support 1. The parts 10, 23, 24, 25, 26, 27 together constitute the aforementioned adjusting device which regulates the speed of the motor 9 in dependency on changes in tension of the band portion 113*a*.

The spring 25 exerts on the cord 24 a pull in a direction to rotate the shaft 23 of the sliding contact clockwise to a position in which the potentiometer 10 causes the motor 9 to rotate the driving rollers 17 at the lowest of a selected range of speeds. This corresponds to a maximum length of the loop which is formed by the band portion 113*a* between the fixed guide rollers 20 and 21. If the band transporting mechanism of the projector subjects the band portion 113*a* to a higher tensional stress, the lever 26 is caused to pivot in a clockwise direction, as viewed in FIG. 1, and the length of the loop between the guide rollers 20, 21 is reduced. This causes the shaft 23 to rotate in a counterclockwise direction, as viewed in FIG. 1, whereby the spring 25 stores additional energy and the sliding contact of the potentiometer 10 assumes an angular position which corresponds to a higher speed of the motor 9 and hence to a higher speed of the driving rollers 17. The tensioning of the band portion 113a which travels into the projector increases when the speed of band withdrawal from the roll 13 is too slow so that the just described detector of the adjusting device for the motor 9 automatically adjusts the speed of the band portion 113*a* as a function of the required band speed in the projector. The spring 25 is free to contract and to cause the potentiometer 10 to reduce the speed of band withdrawal from the roll 13 if the driving rollers 17 rotate the inner roll section 13*a* at a speed which exceeds the required speed of transport of the band through the projector. It can be said that the length of the loop between the fixed guide rollers 20, 21 is indicative of the speed at which the driving rollers 17 rotate the inner section 13*a* of the roll 13.

The band portion 113*b* which leaves the motion picture projector is trained over a fixed guide roller 29, a movable guide roller 31 and another fixed guide roller 30 whence it advances toward the periphery of the roll 13 to be convoluted onto the section 13*b*. The movable guide roller 31 is mounted on a one-armed lever 32 and forms with this lever a second detector forming part of an adjusting device which further includes the potentiometer 12 and serves to regulate the speed of the driving rollers 16 for the outer roll section 13*b*. The lever 32 is mounted on a pivot pin 33 which extends from the underside of the support 1 and the latter has a slot 28*a* for the shaft of the movable roller guide 31. An intermediate portion of the lever 32 is connected with one end of a cable or cord 35 the other end of which is connected with a helical spring 36 anchored in and located at the underside of the support 1. The cord 35 is trained over the shaft 34 of the sliding contact in the potentiometer 12 and the spring 36 urges the cord 35 to rotate the shaft 34 in a counterclockwise direction, as viewed in FIG. 1, whereby the sliding contact of the potentiometer 12 tends to assume a position corresponding to the maximum speed of the motor 11 and driving rollers 16. If the speed of the rollers 16 is too high, the tension in the band portion 113*b* which is about to be convoluted on the outer roll section 13*b* increases and the length of the loop between the fixed guide rollers 29, 30 decreases. The lever 32 pivots in a counterclockwise direction and causes the cord 35 to rotate the shaft 34 in a clockwise direction, as viewed in FIG. 1, so that the potentiometer 12 reduces the speed of the motor 11, turntable 5 and driving rollers 16. If the rotational speed of the rollers 16 is too low so that the tension in the band portion 113*b* decreases, the spring 36 is free to pivot the lever 32 in a clockwise direction, as viewed in FIG. 1, so as to lengthen the loop between the guide rollers 29, 30 and to thereby rotate the shaft 34 in a counterclockwise direction in order to move the sliding contact of the potentiometer 12 to a position which corresponds to a higher speed of the motor 11 and driving rollers 16.

The provision of two groups or sets of driving rollers 16, 17 which respectively support the outer and inner roll sections 13*b*, 13*a* and whose speed can be regulated independently of each other brings about the important advantage that the peripheral speed of the inner and outer sections of roll 13 can be adjusted at will to equal the speed at which the band 113 is being fed into and transported from the projector. This insures that the projector receives successive increments of the band portion 113*a* at the exact speed at which the band must be transported by the pull-down of the projector as well as that the returning band portion 113*b* is properly convoluted onto the outer section 13*b* of the roll 13. It was found that the improved apparatus is capable of fully compensating for the increasing tension which develops in the outermost convolutions of the roll 13 and is attributed to friction between the adjoining convolutions. When the tension in the outermost convolutions increases due to such propagation of friction from the innermost convolutions toward the periphery of the roll 13, the rotational speed of driving rollers 16 is automatically reduced by the adjusting device including the potentiometer 12 so that the outer roll section 13*b* rotates at a reduced speed.

The mutually inclined driving rollers 16, 17 insure gradual transition between the annular outer roll section 13*b* and the annular inner roll section 13*a*. An ad-

vantage of such mounting of the driving rollers **16, 17** that the axes of the rollers **17** are inclined downwardly and outwardly (i.e., away from the axis of the roll **13**) and that the axes of the rollers **16** are inclined downwardly and inwardly is that the rollers **16, 17** effectively prevent undesirable outward shifting of travel of the convolutions. Thus, the convolutions of the inner roll section **13***a* exhibit the tendency to travel outwardly under the action of centrifugal force, and such tendency is counteracted by the outer roll section **13***b* whose convolutions tend to move radially inwardly under the action of gravity and due to the aforementioned inclination of driving rollers **16**.

The improved apparatus can be rapidly and conveniently converted to properly support and rotate rolls having different outer diameters, i.e., rolls storing different lengths of flexible band material. Such conversion can be achieved in a very simple way by changing the mutual inclination of driving rollers **16** and **17** to thus insure that each of the two groups of driving rollers supports substantially one-half of the roll. This brings about a radial shifting of the points P (FIG. 2) where the projections of lines of contact between the rollers **16, 17** and the roll **13** intersect each other. In the illustrated apparatus, the upper end portion **7***a* of the shaft **7** for the upper turntable **6** is provided with external threads which mesh with two nuts **50, 51**. By properly adjusting these nuts, the operator can move the turntable **6** nearer to or further away from the turntable **5** to thereby move the friction wheels **17***a* of the driving rollers **17** to a different level. The turntable **5** can be adjustably mounted on the hollow shaft **4** in addition to or instead of adjustable mounting of the turntable **6**. For example, the shaft **4** may comprise two cylindrical portions one of which is rotatably journalled in the bearing sleeve **3** and the other of which carries the turntable **5** and is adjustable axially of the bearing sleeve **3** to thereby move the turntable **5** to a higher or lower level. It is also possible to provide the upper end portion of the hollow shaft **4** with external threads which mesh with two nuts (similar to the nuts **50, 51**) which are adjustable to thereby change the level of the turntable **5**.

The friction wheels **16***a* and/or **17***a* can be replaced with pinions which mesh with ring gears provided on the respective turntable or turntables.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. In an apparatus for simultaneous convoluting and unwinding of an endless flexible band a substantial length of which forms a roll having a plurality of convolutions including an innermost and an outermost convolution, a first portion of which is integral with said innermost convolution and a second portion of which is integral with said outermost convolution as well as with said first band portion; a combination comprising two groups of driving rollers arranged to extend substantially radially of and to support said roll from below; mounting means rotatably supporting said driving rollers in such positions that the rollers of one of said groups support a first annular section of the roll which includes said innermost convolution and the rollers of the other of said groups support a second annular section of the roll which includes said outermost convolution; and first and second variable-speed drive means for respectively rotating said first and second groups of rollers independently of each other whereby the rollers rotate said roll in a predetermined direction with attendant withdrawal of one of said band portions and convoluting of the other band portion.

2. A combination as defined in claim **1**, wherein the tension of said first and second band portions varies in the course of rotation of said driving rollers, and further comprising first and second adjusting means each associated with a different one of said drive means, said first and second adjusting means being arranged to change the speed of the associated drive means in response to changes in tension of the first and second band portions of that band whose roll is supported by said rollers.

3. A combination as defined in claim **1**, wherein the band is a photographic film and wherein successive increments of one of said band portions enter into and successive increments of the other band portion leave a cinematographic apparatus in response to rotation of the roll in said predetermined direction.

4. A combination as defined in claim **1**, wherein the axes of rollers of said other group are inclined downwardly toward the axis of the roll on said rollers.

5. A combination as defined in claim **1**, wherein the axes of rollers of said one group are inclined downwardly away from the axis of the roll on said rollers.

6. A combination as defined in claim **1**, wherein each of said drive means comprises a substantially horizontal turntable and means for rotating the respective turntable at a plurality of speeds, each of said rollers having a portion in torque-receiving frictional engagement with the respective turntable.

7. A combination as defined in claim **6**, wherein said turntables are coaxial with the roll which is supported by said rollers and the means for rotating said turntables comprise variable-speed motors.

8. A combination as defined in claim **6**, wherein the diameter of one of said turntables exceeds the diameter of the other turntable.

9. A combination as defined in claim **6**, wherein said turntables are mounted at different levels.

10. A combination as defined in claim **1**, wherein the driving rollers of at least one of said groups are inclined with reference to the axis of the roll thereon so that the first axial end of each inclined roller is located at a level above the second axial end thereof, and further comprising means for changing the inclination of said last-mentioned group of rollers.

11. A combination as defined in claim **10**, wherein the drive means for said inclined driving rollers comprises a rotary turntable and each of said inclined rollers comprises a portion at one of said axial ends which is in frictional torque-receiving engagement with said

turntable, said means for changing the inclination comprising means for moving said turntable between a plurality of different levels.

12. A combination as defined in claim 1, wherein the driving rollers of one of said groups alternate with the driving rollers of the other group, as considered in the circumferential direction of the roll thereon, each of said groups comprising at least three substantially equidistant driving rollers.

13. A combination as defined in claim 1, wherein the roll on said rollers is arranged to rotate in a direction to pay out the first band portion and to collect the second band portion, and further comprising adjusting means for changing the speed of at least one of said drive means, said one drive means comprising a variable-speed electric motor and said adjusting means comprising adjustable potentiometer means in circuit with said motor means and detector means arranged to detect changes in the tension of one of the band portion and to thereby adjust said potentiometer means whereby said potentiometer means changes the speed of said motor means as a function of changes in the tension of the last-mentioned band portion.

14. A combination as defined in claim 1, further comprising rotary guide means for the innermost convolution of the roll on said rollers.

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