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(54) Multi-stage prestretch wrapping apparatus and method.

(57) The invention relates to a method for wrapping one or a plurality of components (20) to form a wrapped unitary package by positioning the components on support means (18), positioning a roll (24) of stretchable material adjacent to a roller assembly (26) comprising at least three stretch rollers, prestretching the stretchable material to a predetermined value above its yield point in multiple stages, at least two of which occur through the roller assembly, and wrapping the prestretched material (22) around the components (20) and support means (18). The method may include automatically threading the stretchable material (22) through the stretch rollers. The invention also relates to various apparatus for carrying out these method steps, including a stretch wrapping apparatus, a roller assembly, and an automatic threading mechanism.

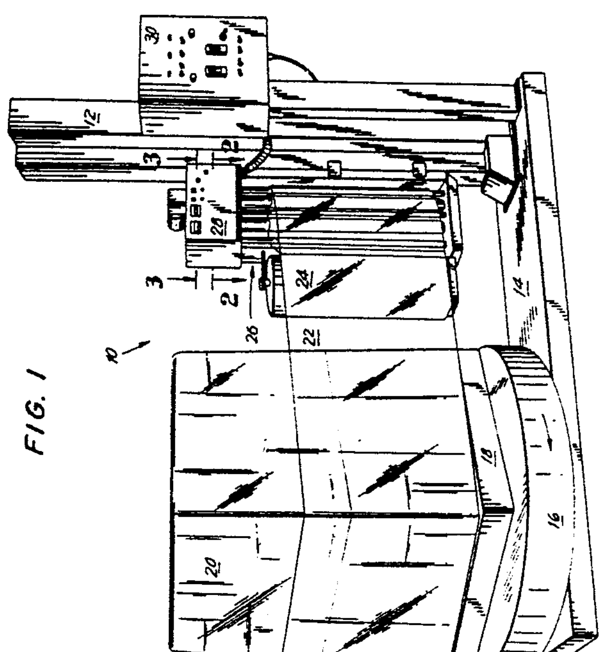


FIG. 1

MULTI-STAGE PRESTRETCH WRAPPING APPARATUS AND METHOD

Technical Field:

The present invention relates generally to packaging and more particularly to an apparatus and method for making unitary packages which hold a plurality of components, each package being wrapped by a stretchable web material.

Background Art:

Case packing or boxing is a common method for shipping multiple component or unit products. One of the earliest methods for shipping such articles was to place the multiple component or unit products in a corrugated box or to wrap them with wrapping paper (i.e. kraft paper), the ends of the wrapping paper being secured by glue or tape. Another way to unitize such articles was to secure them to a pallet through the use of metal or plastic strapping.
Alternatively, a sleeve or covering of heat-shrinkable film was placed around the products and then shrunk to form a unitized package. These well-known methods are still used today for shipping certain items.

A further development in this field relates to the use of a stretchable film material instead of a heat shrinkable material. There, the components are placed on a substrate, slip sheet, support or pallet and a continuous stretchable film web of the same size as the load is wrapped around the components and pallet to form the unitized package. The film is stretched by the use of braking or otherwise retarding the feed roll of stretchable web material. The stretchable webs which have been so utilized are most often made from plastics such as nylon, polyethylene, polypropylene, polyvinylchloride (PVC), polybutylene, or any copolymers or blends of these materials.

Another improvement in this field relates to the use of spiral stretch-wrapping machinery. Such devices are well known; they operate by restrictively feeding a relatively narrow film from a roll and wrapping it around a load in a spiral configuration. A carriage lifts the film roll adjacent to the surface of the load to deposit a first spiral overwrap around the load and then descends to deposit, another spiral overwrap in the opposite direction. Also, a plurality of spiral wrapped film layers can be used. It is also known to wind tapes spirally in a manner such that they do not overlap each other, so as to provide suitable space therebetween when "breathability" is required. The spirally wound tapes intersect one another at a suitable angle, depending upon the application intended.

Other applications in packaging include wrapping a heat shrinkable, tensioned, cling, or tacky PVC film around a pallet supporting a plurality of cartons. Further, a number of rotatable drives for supporting pallets and loads to be wrapped are well known in the art.

The elasticity of the plastic web holds the products under greater tension than either the shrink or paper wraps, particularly with products which settle when packaged. The effectiveness of stretched plastic film in holding a load together is a function of the elastic recovery forces being placed on the load and the ultimate strength of the total layered film wrap. These two functions are determined by the modulus of the film and its ultimate strength after application.

The ultimate containment force is achieved in these methods by maximizing elongation of these films to a point just below where breakage or rupture would occur. The stretch films used in these methods, however, are stretched much less than about 200% in field applications (typically on the order of about 50-125%), because of irregularities in the film braking system, which depends upon the direct or indirect application of friction forces to restrict the roller upon which a supply of film is positioned.

The prior art wrapping devices suffer from a further limitation with respect to cost per unit load for film unitization. For example, friction brake devices do not normally maintain a consistent force, and are subject to variation due to their physical construction and their sensitivity to speed change caused by the passage of corners of the load, or the resultant sudden speed up and slow speed down of film unwind. A typical 40" × 48" rectangular pallet load will incur a surface speed change of more than about 40% with each quarter turn by reason of the change in effective radius. Moreover, higher turntable speeds produce additional forces, which can also change with roll consumption and its resultant weight change.

In view of the aforementioned drawbacks of film stretching and braking devices, it will be appreciated that many of the known stretch-wrap packaging machines have limited capabilities. One limitation is that, when the films are stretched at high elongation rates, the necessary forces tend either to disrupt the stacking pattern or to pull the load off the turntable. In addition, non-vertical sides and corners on irregular loads place a great deal of force on a small area of film during stretching, thereby causing a partial rupture at a point well below the force achievable on a flat side. This partial rupture causes a transfer of force to the remaining portion of the web which, in turn, can produce a "zippering" effect upon the entire film web.

One solution to this problem has been proposed whereby the film is prestretched before wrapping it around a load. The film was stretched from between 40 and 300% before wrapping so that the load would be protected from the stretching forces but still held by compressive forces. This technique disclosed, for example, in French patent No. 2,281,275 and U.S. Pats. Nos. 4,418,510 and 4,336,679.

Film of polyethylene, polyvinylchloride and various copolymers all are stretchable. The stretch rate, however, has a significant effect on the ability of the film to elongate. This phenomenon of stretch rate versus amount of elongation is evident in most deformable materials. Commercially available stretch films are manufactured with specific low density and linear low density properties. These resins and manufacturing process conditions are designed to produce tough, stretchable, thin gauge films which can be used in conjunction with any commercial stretch wrapping equipment.

In order to understand the stretch wrap packaging art, the following definitions are helpful.

Stretch Wrap Material: A material used for overwrapping which, when applied under tension, elongates and through elastic recovery, conforms to the item(s) packaged.

Elongation : Increase in length expressed as a percentage of original length.

Elastic Recovery: The change in elongation upon release of the applied tension.

Conventional Braking : A mode of stretch wrap machinery operation in which stretch wrap material elongation is achieved by relative load motion and supply roll tension.

Prestretch: A method of elongating stretch wrap material prior to its application to the load.

Mechanical Prestretch: A conventional mode of stretch wrap machinery operation in which stretch wrap material elongation is accomplished at least in part through the use of two mechanically-interconnected rollers and without the utilization of power means such as a motor.

Powered Prestretch: A conventional mode of stretch wrap machinery operation in which stretch wrap material elongation is achieved through the use of two mechanically-interconnected powered rollers, such as by individually motorized rollers.

Upstream: This refers to a direction toward the film supply, i.e., opposite the direction of movement of the film.

Downstream: This refers to a direction toward the load to be wrapped, i.e., in the same direction as the movement of the film.

At the start of a typical stretch wrapping operation, a loaded pallet is placed on the turntable. The film is attached to the load. The turntable rotates, thus pulling the film from the supply roll. Several commercially available stretch wrapping units rotate around the stationary pallet load. With conventional equipment, a braking method restricts the rotation of the film supply roll causing tension between the rotating load and the supply roll. This tension stretches the film.

The principal reason for prestretching the film is to achieve greater containment strength and economy in the use of plastic stretch films, while isolating the load from the high forces needed to accomplish the required stretching. Typical polyethylene film will multiply three times the ultimate strength in pounds per square inch of cross-sectional area after being elongated approximately 300%. This significant increase in strength begins approximately when the yield point is exceeded in elongation.

Non-powered mechanical prestretching equipment is similar to conventional equipment, except that the film is threaded through a prestretch device. The prestretch device may consist of two interconnected but non-powered rollers as, for example, in U.S. Pat. No. 4,302,920. The upstream roller rotates at a slower speed than the downstream roller. Assuming no slippage between the film and the rollers, the relationship between these two speeds determines the percentage of stretch. Properly selected material and roller design creates a strong dynamic frictional force between the rollers and the stretch film which prevents the film from slipping.

Powered prestretch equipment is similar to mechanical prestretch equipment except that the power devices have one or more motors powering the prestretch rollers. These motors, through an appropriate connection, drive the rollers different speeds to elongate the film above its yield point and deliver prestretched film to the load. This feature is disclosed, for example, in French Patent No. 2,281,275 to Thimon. Alternately, it is possible to achieve the same result by powering a downstream roller while braking or mechanically restricting an upstream roller.

U.S. Pat. No. 4,418,510 discloses a very similar, if not identical, concept wherein two rollers, mechanically connected and powered by a single motor, are used to stretch the film above its yield point. Again, the different speeds of these rollers cause the film to elongate beyond its yield point. As the film travels between the downstream powered roller and the relatively rotating load, its speed is reduced. The reduction in speed is such as to decrease the force applied to the load through "non-elastic strain recovery." The foregoing is disclosed as being particularly advantageous for protecting unstable or crushable loads.

U.S. Pat. No. 4,458,467 discloses a tensioner assembly which prestretches a film web in three stages. As in the non-prestretch devices, the first stage of stretch occurs between the retarded feedstock roll and the upstream prestretch roller. The second stage of stretch occurs between the upstream and downstream rollers, while the third stage of stretch occurs between the downstream roller and the pallet load; the web is maintained under tension at all times by a resiliently braced dancer roller. The degree of stretch in the first and third stages in this system is relatively low compared to the degree of stretch between the two rollers and thus, does not appear to provide an appreciable advantage over the schemes of French patent No. 2,281,275 and U.S. Pat. No. 4,418,510, which use two rollers under power rotating at different speeds.

Many pallet loads are approximately cubic or rectangular in shape. It is evident that the surface speed of such loads is greater at the corners than at the flat sides. Also, the position of the load on the rotating turntable can contribute to this speed variation. These varying speed demands from the load translate into varying forces upon the film and its resultant relative stretch.

With a conventional prestretching apparatus, the higher speeds at the corners create higher levels of elongation at the corners, assuming constant turntable speed and constant braking force. Mechanical prestretch displays an even higher stretch at the corners. Known powered prestretch systems usually are equipped with controlling devices to increase or decrease the speed of the prestretch system relative to the load requirements, thus maintaining a nearly constant level of elongation. Without providing an adjustment for the speed variation due to the load, however, the rate of stretch can vary greatly.

SUMMARY OF THE INVENTION

The present invention provides a novel method, and apparatus for prestretching plastic web or film material in mutiple stages. Preferably, at least three stages are used: two or more of these stages occurring between pairs of powered stretch rollers. This allows the film to be prestretched to an optimum value without breaking or rupturing.

Generally, the invention relates to a method for wrapping one or a plurality of components to form a wrapped unitary package which comprises positioning a load comprising one or a plurality of components onto support means, providing a supply of stretchable material, providing a plurality of powered stretch rollers between the supply and the load, prestretching the material to a predetermined value in multiple stages comprising first, second and last prestretching stages, and wrapping the prestretched material around the one or plurality of componets on the support means.

The prestretching stages can occur between the supply and a first roller, between a pair or stretch rollers, or between a stretch roller and the load. Preferably, at least two prestretch stages occur between two pairs of stretch rollers. Also, idler rollers can be provided to guide the material between the supply and the load.

Furthermore, this method is applicable to any type of stretch wrapping equipment, including those in which the load is rotated or moved and the supply and/or prestretching equipment is stationary; the supply and/or prestretching equipment is moved or rotated while the load is stationary; or combinations thereof.

One aspect of the invention relates to a method for wrapping a plurality of units or components to form a unitary package which comprises positioning a load including one or a plurality of components onto support means, positioning a roll of stretchable material adjacent a roller assembly comprising at least three rollers adapted to stretch the material according to predetermined values; prestretching the stretchable material to a predetermined value above its yield point in multiple stages through the roller assembly, and wrapping the prestretched material around the one or plurality of components on the support means.

Also, a method for wrapping one or a plurality of components to form a wrapped unitary package is provided, which comprises supporting a load comprising one or a plurality of components; providing a supply of stretchable material; directing the stretchable material to three or more rollers adapted to stretch the material according to predetermined values; prestretching the material between the supply roll and a first stretch roller; further prestretching the stretchable material to a predetermined value above its yield point between a second pair of stretch rollers, and wrapping the further prestretched material around the one or plurality of components to form wrapped unitary package.

These methods may also include automatically threading the stretchable material between the rollers, initially prestretching the material between the material supply and a first stretch roller, or additionally prestretching the material between the stretch roller immediately upstream from the load and the load.

Prestretching of the material is achieved by driving each downstream roller of any pair of stretch rollers at a faster speed than the upstream roller. Also, by maintaining the distance between the rollers of each pair of stretch rollers sufficiently close to each other, the reduction of widthwise dimension of the wrapping material is minimized during the prestretching steps.

An alternate method comprises supporting a load comprising one or a plurality of components providing a supply roll of stretchable material, directing the stretchable material to three or more rollers adapted to stretch the material according to predetermined stretch values, prestretching the material to a predetermined value between the supply roll and a first stretch roller, further prestretching the material to a predetermined value between one or more pairs of stretch rollers, and wrapping the further prestretched material around the one or plurality of components to form a wrapped unitary package. In this method, it is preferable to prestretch the material above its yield point between the supply roll and the first stretch roller.

The invention also relates to an improvement in a method for wrapping a load comprising one or a plurality of units or components with a stretchable wrapping material. This improvement comprises prestretching the stretchable material to a predetermined value above its yield point in multiple stages. Each of these stages preferably comprises prestretching the stretchable material between a pair of stretch rollers. Thus, the multiple prestretching stages comprises at least three stretch rollers driven at different speeds according to a predetermined ratio. Also, the multiple stages may include a first stage wherein the stretchable material is prestretched above its yield point between a material supply and a first stretch roller, and one or more second stages wherein the prestretched material is further prestretched between a pair of stretch rollers. In either case, the stretchable material may be additionally prestretched between the stretch roller immediately upstream from the load and the load.

Another aspect of the invention relates to an apparatus for wrapping one or a plurality of components to form a unitary package comprising support means for holding one or a plurality of components, means adjacent to the support means for dispensing stretchable material, means for prestretching the stretchable material to a predetermined value above its yield point in multiple stages, and means for wrapping the prestretched material around the one or plurality of components on the support means.

In this apparatus, the prestretching means may be a series of at least three stretch rollers, each prestretching stage occurring between a pair of stretch rollers. The relative speed between the rollers of any pair of stretch rollers is controlled by gear, pulley or other suitable means. Preferably the relative speed between the two fastest rotating pair of stretch rollers is controlled and adjusted by gear means and the relative speed between the slowest rotating pair of stretch rollers is controlled and adjusted by pulley means. It is also possible for the relative speed of the fastest rotating pair of stretch rollers to be controlled and adjusted by pulley means and the relative speed between the slowest rotating pair of stretch rollers to be controlled and adjusted by gear means. The stretch roller having the greatest peripheral surface velocity is most advantageously driven by motor means. Also, if desired, each stretch roller can be driven by motor means, with each motor means mechanically or electrically connected to the others. In addition, means for automatically threading the stretchable material through the stretch rollers can be provided.

Another aspect of the invention relates to a powered roller assembly for prestretching stretchable material comprising at least three stretch rollers driven at different speeds according to a predetermined ratio such that the material becomes elongated to a predetermined value above its yield point in multiple stages, each prestretching stage occurring between a pair of stretch rollers. It is possible to control the relative speed between any pair of stretch rollers by gear means or pulley means as described above, or by driving each stretch roller by motor means. The stretch rollers may be sufficiently close to each other to reduce the length of the film in engagement therebetween, thereby limiting the reduction of widthwise dimension of the film during prestretching. This distance should be sufficient to prevent contact of the rollers up to about 1/4 inch, measured tangentially from the outer surfaces of the rollers along the axes of the roller shafts.

The above-mentioned purposes and operations of the invention are more readily apparent when read in conjunction with the following drawing descriptions and the detailed description of the preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the present invention will be more readily apparent with reference to the accompanying drawing figures, wherein:

FIG. 1 is an overall view of a stretch wrapping apparatus according to the present invention;

FIG. 2 is a top view partially in cross-section taken along lines 2--2 of FIG. 1;

FIG. 3 is a top view partially in cross-section taken along lines 3--3 of FIG. 1;

FIG. 4 is a cross-sectional view taken along lines 4--4 of FIG. 2;

FIGS. 5 and 6 are detailed views of the pulley and gear assemblies for the roller assembly of FIGS. 2-4;

FIG. 7 is a side view of a supply roll brake/tensioner assembly for the film supply roll and input footage counter;

FIG. 8 is a top view partially in cross-section of an alternate embodiment of the invention taken along the lines 2--2 of FIG. 1;

FIG. 9 is a top view of a dancer roller/motor actuation switch for the embodiment of FIG. 8; and

FIGS. 10 and 11 are views similar to FIGS. 5 and 6 which illustrate an alternate interconnection of the roller pulley and gear assemblies of FIG. 8;

FIG. 12 is a schematic which illustrates the changes in speeds around a typical load for the wrapping apparatus of the invention; and

FIG. 13 is an exploded view of the controller means for FIG. 1 illustrating the counters for length of film dispensed and prestretched.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to a novel method and apparatus for prestretching a stretchable material, such as plastic film, to a predetermined value above the yield point of the film in multiple prestretch stages, at least two of which occur between pairs of stretch rollers in a powered roller assembly having at least three stretch rollers. Additional prestretch stages can be utilized to distribute the total amount of stretching to a plurality of smaller prestretching amounts. This apparatus is useful with any type of wrapping apparatus, including the rotating turntable, roll wrapping, spiral wrapping, full web (or full film width) wrapping, pass-through; overhead, and ring wrapping types. The apparatus can also be used to prestretch film for bundling relatively small loads. For illustration purposes, the methods and apparatus of the invention are described for use with a rotating turntable stretch wrapping apparatus.

An overall view of the improved wrapping method as practiced on the apparatus of the present invention is shown in FIG. 1. The apparatus 10 includes an upright frame 12 and base 14. Means for rotation, which is illustrated in FIG. 1 as a turntable 16, is mounted on base 14.

Conventional support means such as pallet 18 is positioned upon the turntable 16, and a plurality of units or components 20 to be wrapped are stacked on this pallet. A roll 24 of stretchable plastic film 22 is, located adjacent the turntable 16. The film supply is indicated as being of standard width (i.e. between about 20 and 30"), however, the invention is operable with any size (width) film provided that the appropriate increase in size of the stretch rollers and roller driving means are utilized. As will be described in further detail hereinbelow, the film 22 is prestretched between the film supply 24 and a first stretch roller before being further prestretched through a roller assembly 26 in at least two stages and attached to the plurality of components 20 to facilitate wrapping.

The powered roller assembly 26 also includes first programmable controller means 28 for setting the speeds of different rollers at predetermined values. This may be a computer or a mechanical device. Also, the powered roller assembly 26 includes a second programmable controller means 30 which is capable of varying the height of the plastic film and rollers in a vertical direction so as to completely wrap the entire plurality of components 20 on pallet 18.

Referring to FIG. 2, tension can be provided on the film by the use of a core brake 48 on the film supply 24. It is preferable to set the core brake at a sufficiently high level such that the film 22 is prestretched to a predetermined value between the film supply 24 and the first stretch roller 34. It is possible, if desired, to prestretch the film 22 above its yield point at this location, that is, before the film proceeds to the powered roller assembly 26 for further prestretching before contacting and wrapping the load.

Referring again to FIG. 2, there is also illustrated a top view of the roll 24 of stretchable plastic film and the powered roller assembly 26. The leading edge of the film 22 passes around guide roller 32 and thereafter around stretch rollers 34, 36 and 38. Next, the prestretched film passes around dancer roller 40 and exit guide roller 42 before being attached to the load to be wrapped. A prestretching stage of the film occurs between rollers 34 and 36 and, according to a preferred embodiment, the film is not prestretched above its yield point in this stage. Another prestretching stage occurs between rollers 36 and 38 and the remaining degree of prestretching to the desired amount can be provided there. Additional prestretching can be accomplished through the use of additional pairs of stretch rollers. Also, the prestretched film can be further prestretched between the last stretch roller 38 and the load.

FIG. 2 also illustrates an automatic threading mechanism which is used to initially introduce the film around the stretch rollers. This safety mechanism avoids the danger of an operator catching his fingers between the rollers, and provides a much faster method for threading the film. This assembly is in the form of two guide plates 44, 46, which fit into notches in the stretch rollers 34, 36, 38 such that the film may only pass in one direction, thus wrapping itself around the stretch rollers. In order to thread the film 22 around the stretch rollers, the film supply 24 is advanced to supply a leading edge of film. After being directed around guide roller 32, the film is bunched up and then inserted between roller 34 and guide plate 44 at position A. The roller assembly 26 is then powered for a short period of time, and the rotation of the stretch rollers causes the film to be drawn between the rollers and the guide plates, thus rapidly and automatically threading the film around the rollers. The leading edge of film exits the roller assembly 26 at point B, and is directed around dancer roller 40 and exit guide roller 42 before being attached to the load. After attachment of the film to the load, the stretch rollers are engaged to prestretch the film to the desired amount before wrapping the plurality of components on the support means.

FIG. 4 illustrates the relationship between the guide plates and the notches in the rollers, as well as the orientation and position of the film after being threaded around the rollers. This figure also shows one way of attaching guide plate 46 to the frame of the roller assembly housing. As one skilled in the art would realize, other means of attachment such as welding or the like can also be used to place the guide plates 44, 46 in the appropriate positions.

Prestretching of the film in the powered roller assembly 26 is accomplished by rotating the downstream roller of each pair of stretch rollers at a faster speed than the upstream roller. Thus, roller 38 is rotated at a faster speed than roller 36 and roller 36 is rotated at a faster speed than roller 34. To obtain 300% stretch, for example, the degree of prestretch of the film is distributed over three stages: e.g., between the film supply 24 and the first stretch roller 34; between rollers 34 and 36; and between rollers 36 to 38 to provide a total of 300% for these three prestretching stages. The purpose of stretching the plastic film material in multiple stages is to allow sufficient time for the molecular structure of the film to establish its new orientation after undergoing the initial prestretch. This time, which is also referred to as a relaxation period or recovery, enables the film to provide improved resistance to breaking, rupturing, or tearing for the same degree of stretch that is provided in a one stage or single step prestretching system, thus increasing the strength per pound per square inch of film.

Referring to FIGS. 5 and 6, there is illustrated the pulley and gear assemblies which drive the stretch rollers 34, 36, 38 of the invention. The fastest rotating roller 38, is driven or powered directly by a motor/gear reducer assembly 60. As roller 38 rotates, gear 62, mounted on the shaft of roller 38, engages gear 64 mounted on the shaft of roller 36. Therefore, the speed of rotation of roller 38 is fixed by motor/gear reducer assembly 60, whereas the relative speed between rollers 36 and 38 is determined by the ratio of gears 62 and 64. In the most preferred embodiment, roller 38 is driven twice as fast as roller 36. However, as one skilled in the art would realize, by changing the gear ratio between rollers 36 and 38, any of a wide variety of speed ratios between these rollers can be obtained.

Roller 36 also has a second gear 66 mounted on its shaft. This gear 66 engages gear 68 of a idler shaft 70 which is not connected to any stretch roller. As roller 36 rotates, gear 66 engages gear 68 and transmits rotational forces to shaft 70. Also located on shaft 70 is pulley 72. Pulley 72, through belt 76, engages pulley 74 which is mounted on the shaft of roller 34. Since pulleys 70 and 74 are variable speed, some degree of operational control between the speeds of rollers 36 and 34 can be provided due to the variability of the pulley speeds. FIG. 5 shows pulley 72 in a relatively slow speed position with pulley 74 in a high speed position. FIG. 6, however, shows the reverse, i.e. pulley 74 is in the low speed position and pulley 70 is in a high speed position. Since the distance between the shafts of the pulleys is fixed, the variable speed feature of the pulleys is important to maintain belt 76 in proper tension and contact with the pulleys 70, 74 so as to maintain the transmission of rotational force from roller 36 to roller 34. It is also possible to include a control 78 to allow the operator to change the relative speeds of the pulleys 70, 74. This control, which can be manually or automatically operated, adjusts the spring loading on pulley 74. Such loading changes the speed of pulley 70, which rotates in response to the speed of pulley 74 transmitted by belt 76. Furthermore, if a greater degree of adjustment between the speeds of rollers 34 and 36 is required, the ratio of gears 66 and 68 can be changed. It is most preferable to rotate roller 36 appropriately twice as fast as roller 34. Those skilled in the art can best determine the relative speeds between rollers 34, 36 and 38 to obtain the appropriate amount of prestretching, as well as to determine the desired number of stages of powered stretch rollers, to achieve the overall amount of prestretching of the film before wrapping the load.

The control of motor/gear reducer assembly 60 by the action of dancer roller 40 increases or decreases the speed of the motor/gear reducer assembly 60. The position of the dancer roller 40 is governed by the film demand.

The multiple stage prestretch system of the present invention reduces the effective rate of stretch on the film compared to conventional single stage prestretching at identical percentages of elongation. When maintaining identical rates of stretch, the use of multiple prestretch stages produces higher levels of stretch. Since the multi-stage prestretch system of the invention also slows the rate of stretch, a higher effective percentage of stretch can be achieved compared to a single prestretch stage system.

FIG. 12 is a schematic which illustrates the changes in speeds at the corners of a typical load for the wrapping arrangement of the invention. If a given stretch film has the ability to be elongated at a given rate of acceleration in a single stage prestretch system (i.e. having two rollers), a multi-stage prestretch system (i.e. one having three or more rollers) will increase the actual ultimate elongation of the film. If a given film cannot elongate at the accelerations required for a given elongation, the three roller design will lower these accelerations, therefore allowing higher elongation levels and reduced consumption of film per unit area. Optionally, the present invention provides stretch between the supply and the first upstream stretch roller and/or between the last downstream stretch roller and the load so as to distribute the prestretch over additional stages. Stretching between the last downstream stretch roller and the load is sometimes referred to as poststretching. After the film is stretched to the desired amount in the appropriate number of stages, it is then wrapped around the load.

Elastic recovery is a "rubber-band" effect that enables stretch wrap materials to encapsulate the load. Prestretching, which enables a film to reach higher percentages of stretch, however, also reduces the elastic properties of the film. A single step, very high degree prestretching step orients a stretch film, causing the film to become brittle and have reduced elastic recovery. This brittleness is a result of the molecules being oriented i.e., becoming arranged to form chemically bonded chains of molecules which increases the tensile strength in the direction of orientation. Slower stretch rates will allow the molecules to reorient, therefore reducing this brittleness. By using three or more rollers (i.e., two or more prestretching stages), prestretch with lower stretch rates are obtained which, in turn, reduces the resultant brittleness of the film. The multi-stage stretch system will also allow higher levels of stretch while reducing the associated loss of elastic recovery.

FIG. 3 shows the physical interconnection of the gears and pulleys on the top of the roller assembly 26. This figure also illustrates the movement of the position of the dancer roller 40. This dancer roller 40 is biased by spring 41 to hold lever arm 43 against switch 82 to maintain the speed of motor 60 at a minimum value. The degree of spring biasing can be easily varied by adjustment screw 45. In addition, screw 45 can be used to adjust the tension on the dancer roller 40, with the greater the tension on the dancer roller providing greater tension on the film. The position of dancer roller 40 can vary in slot 80, which allows movement of the roller due to differences or changes in demand of the film. The movement of the axis of the dancer roller 40 in this slot also actuates multiple position switch 82, to increase the speed of the motor 60. An example of the operation of this portion of the unit follows.

After the film is connected to the load and the load is rotated, the demand at which the prestretched film is wrapped around the load varies depending upon the size and shape of the load. As mentioned above, when the load is square or rectangular, the film wrapping demand at the corners of the load is much greater than that of the sides. When the demand of the film is accelerated, the spring biased dancer roller 40 moves to one side of the slot, thus actuating the switch which accelerates the speed of the motor and prestretching rollers. As the motor accelerates, the supply of prestretched film is increased. The supply of prestretched film attempts to increase to "catch-up" to the increased wrapping speed encountered on the sides of the load. When the sides of the load are encountered, the film demand decreases, and the spring returns the dancer roller towards the opposite end of the slot, thus positioning the switch for lower motor speeds and slowing the rate of supply of stretched film to correspond the supply rate to the lessened film demand and wrapping rate. As the film demand again increases (for example, when contacting another corner of the load), the dancer moves back to again position the switch for faster motor speeds. Later, when the film demand again decreases, the roller moves away from the high speed speed switch. As mentioned above, switch 82 has multiple positions corresponding to various motor speeds. As the load is wrapped, the dancer roller 40 continually moves back and forth, positioning the motor drive switch to apply faster or slower speeds to the motor in a continuous attempt to correspond the rate of prestretched film supply to the actual film wrapping rate or demand.

Referring again to FIGS. 2 and 7, in order to determine how much film is dispensed from the film supply 24, a counter wheel 50 is,provided. This wheel is mounted on an arm 52, connected to pivot point 54, which enables the counter wheel to contact the outer diameter of the film supply 24 as that diameter decreases during operation of the wrapping apparatus. The counter wheel includes a preloaded spring 55 which maintains forces on the wheel 50 to provide tension against the film supply 24. This mechanism is designed to provide two functions: it lessens brake tension as the size (diameter) of the film supply diminishes and acts as a dispensed film footage counter. A counter mechanism 56, for counting the number of revolutions of the counter wheel is also provided. A potentiometer 53 supplies the values needed for the setting of the core brake as the supply roll 24 diminishes to ensure even tension as the film enters the prestretch mechanism 26. For convenience, the counter wheel 50 is made of the same diameter as the stretch roller 38.

Roller 38 is also .provided with a counter mechanism 58, which is identical to the counter mechanism 56 of wheel 50, to count the revolutions of roller 38. This information is used in conjunction with the information from counting mechanism 56 to measure the amount of elongation or prestretch of the film.

The percentage of stretch between the film supply 24 and the last stretch roller 38 can be calculated by the following formula:

$$\% \text{ stretch} = \frac{B-A}{A} \times 100\%$$

where B is the number of revolutions of roller 38 per unit time, as measured by counter 58, and A is the number of revolutions of wheel 50 for the same unit time, as measured by counter 56. If the appropriate diameters are selected for the counters, these A and B values can directly measure the length (feet) of film dispensed. For example, if, for the same unit time, A measures 123 feet and B measures 492 feet, the percentage of stretch is

$$\frac{492-123}{123} \text{ X } 100 = 300\%.$$

As noted above, the diameter of roller 38 and wheel 50 are identical so that this simple formula to be used. Also, as shown in FEG. 13, the number of feet or revolutions can be displayed on digital counters 57, 59, on the controller means 30. This facilitates the calculation and monitoring of the percentage of stretch. Also, a microprocessor can be used to automatically and continuously calculate and display this value.

Referring now to FIG. 7 there is illustrated a detail of the counting wheel 50 to illustrate how contact of wheel 50 on film supply 24 is achieved through the use of spring 55. While those skilled in the art can devise alternate ways of arranging this mechanism, the design shown has been found to be particularly advantageous for maintaining contact while the film supply diminishes.

FIGS. 8, 10 and 11 show an alternate embodiment for the connection of the gears and pulleys of the stretch rollers for maintaining the relative speeds between these rollers. An alternate mechanism for the dancer roller motor speed control is shown in FIG. 8 and detailed in FIG. 9. This mechanism is similar to that disclosed in FIG. 3, and it can be used in the same manner to control the speed of the motor as well as the tension of the film. In this embodiment, roller 38 is again powered directly by motor/gear reducer assembly 60. As roller 38 rotates, gear 62, which is mounted on roller 38, engages gear 64 which is mounted on roller 36. Thus, the rotation of roller 38 causes roller 36 to rotate. Depending upon the ratio of gears 50 and 48, the relative speed of rollers 38 and 36 can be controlled. Preferably, roller 38 rotates about twice as fast as roller 36. As roller 36 rotates, pulley 90, located on the shaft of roller 36, is also caused to rotate. Pulley 90 causes idler shaft 96 to rotate by engaging pulley 94 with belt 92. Shaft 96 also includes gear 98. Gear 98 engages gear 100 on the shaft of roller 34, so as to rotate roller 34. Some degree of operational control is provided between rollers 36 and 34 due to the variability of the pulley speeds. FIG. 10 shows the pulleys in position for one speed, while FIG. 11 illustrates an adjustment for increasing the speed of pulley 94. It is also possible to include a manual or electrically operated control 78 to change the relative speeds of the pulleys 90, 94. Also, gears 98 and 100 contribute to the control of the relative speed of rollers 36 and 34.

FIGS. 5, 6, 10 and 11 illustrate the adjustable feature of the pulleys. These pulleys are variable in width to provide various effective pulley diameters depending upon whether the pulley halves are adjusted to be closest to each other - i.e. maximum diameter as in FIGS. 5 or 10 or farthest (minimum diameter) as in FIGS. 6 or 11. Pulleys 70 and 90 are spring biased away for maximum diameter from each other and thus when loosening the control 78, the belt automatically pushes the pulley halves apart as shown in FIGS. 6 and 11.

This invention also contemplates the use of the motor to directly drive any of the three rollers with the proper interconnecting gears or pulleys to drive the remaining rollers at the predetermined speeds. Other arrangements are, of course, possible but the two embodiments described hereinabove appear to be the most efficient for a system of this type.

It is also possible to use more than three stretch rollers in the roller assembly if additional prestretch stages are desired or needed. In addition, it is possible to add one or more idler rollers to the roller assembly. Such idler rollers may be used for specialty applications. When used, these idler rollers can be located before, after or between pairs of stretch rollers without departing from the multiple stage prestretching concepts of this invention. Also, as noted above, it is possible to prestretch the film between the supply and the first stretch roller or between the last stretch roller and the load to provide additional stages.

While it is apparent that the invention herein disclosed is well calculated to fulfill the objects above stated, it will be appreciated that numerous modifications and embodiments may be devised by those skilled in the art, and it is intended that the appended claims cover all such modifications and embodiments as fall within the true spirit and scope of the present invention.

Claims

1. A method for wrapping one or a plurality of components to form a wrapped unitary package which comprises:

positioning a load comprising one or a plurality of components onto support means;

providing a supply of stretchable material having a yield point;

providing a prestretch mechanism comprising a plurality of [powered] stretch rollers including first, second, and third stretch rollers between the supply and the load;

prestretching the stretchable material to a value above its yield point by means of the prestretch mechanism in successive stages between the first and second stretch rollers and between the second and third stretch rollers respectively; and

wrapping the prestretched material around the one or plurality of components on the support means.

2. The method of claim 1 further comprising initially prestretching the material to a lower value between the supply and the first stretch roller.

3. The method of claim 1 wherein the first, second, and third stretch rollers are powered such that each of said stages occurs between a pair of said powered stretch rollers.

4. The method of claim 1 further comprising further prestretching the prestretched material to a higher value between one of said stretch rollers of the prestretch mechanism and the load.

5. The method of claim 3 further comprising initially prestretching the material to a lower value between the supply and the first stretch roller and further prestretching the material to a higher value between one of said stretch rollers of the prestretch mechanism and the load.

6. An apparatus for wrapping one or a plurality of components to form a unitary package comprising:

support means for supporting one or a plurality of components;

means adjacent the support means for dispensing stretchable material having a yield point;

means for prestretching the stretchable material to a predetermined value above its yield point in multiple stages, said prestretch means including at least first, second, and third stretch rollers for prestretching the stretchable material in successive stages between the first and second stretch rollers and between the second and third stretch rollers respectively; and

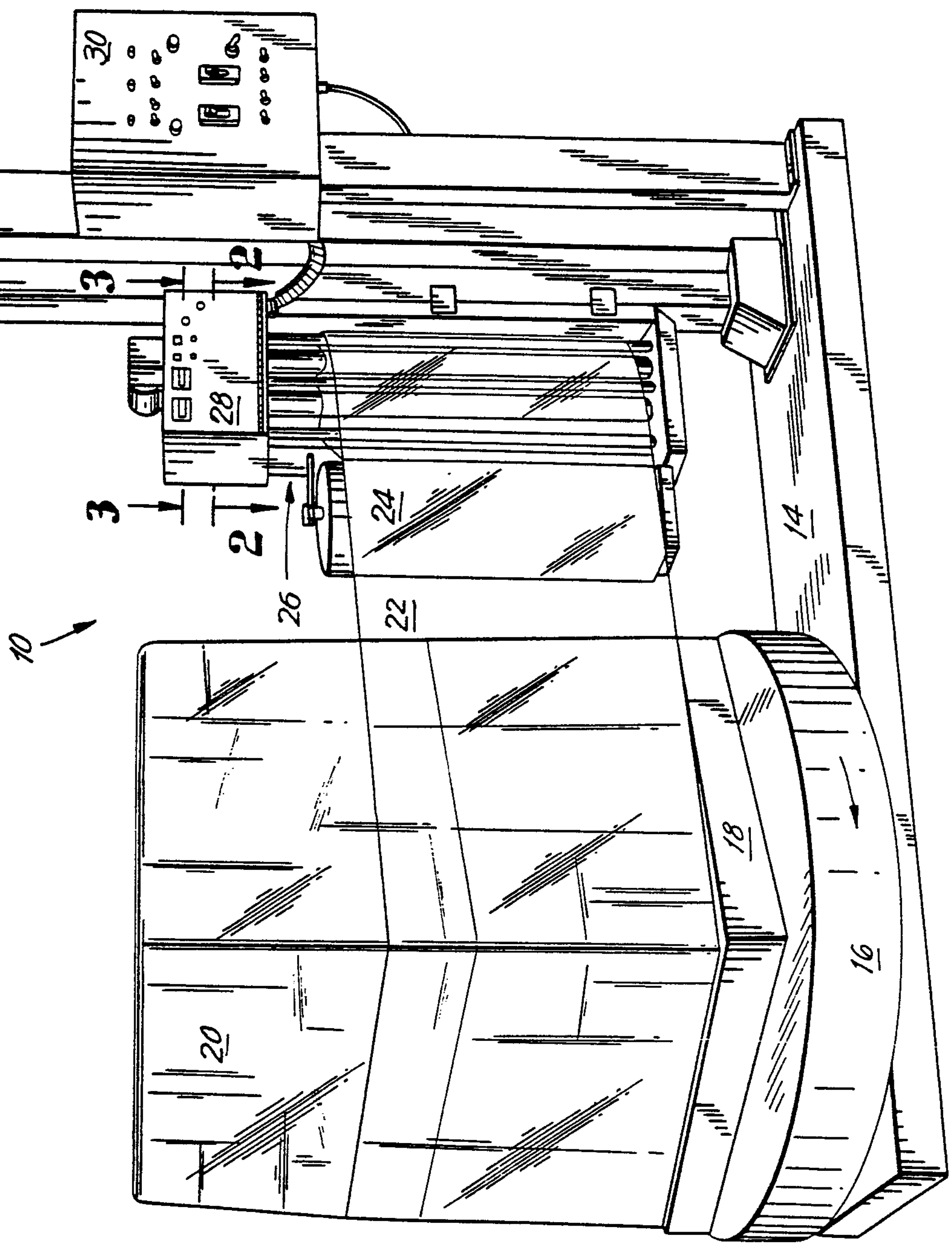
means for wrapping the prestretched material around the one or plurality of components on the support means.

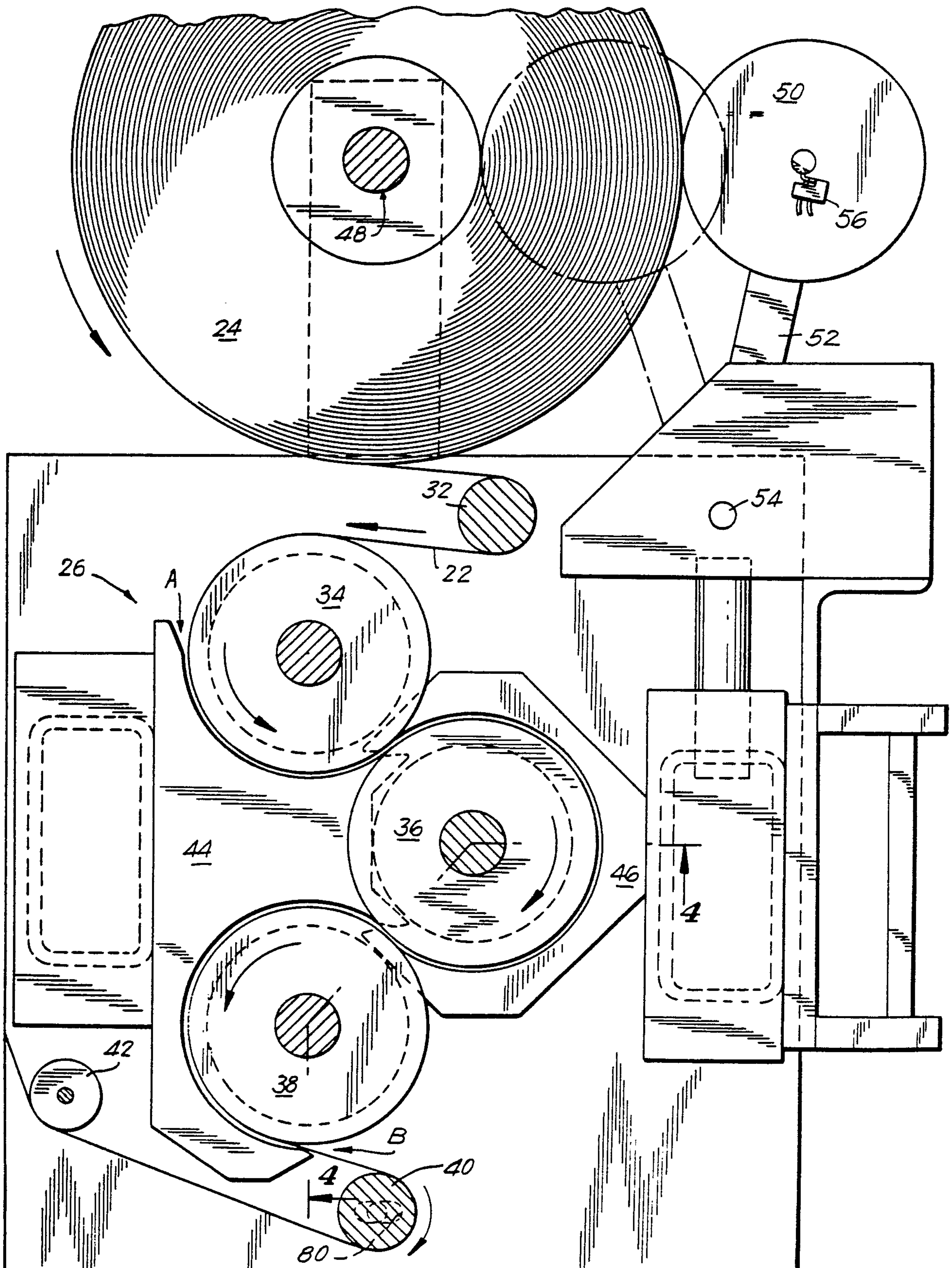
7. The apparatus according to claim 6 wherein the relative speed between the rollers of any pair of said stretch rollers is controlled by gear means or pulley means.

8. The apparatus according to claim 6 wherein each stretch roller is driven by motor means, and each motor means is mechanically or electrically connected to the others.

9. The apparatus according to claim 6 wherein the stretch roller having the greatest peripheral surface velocity is driven by motor means.

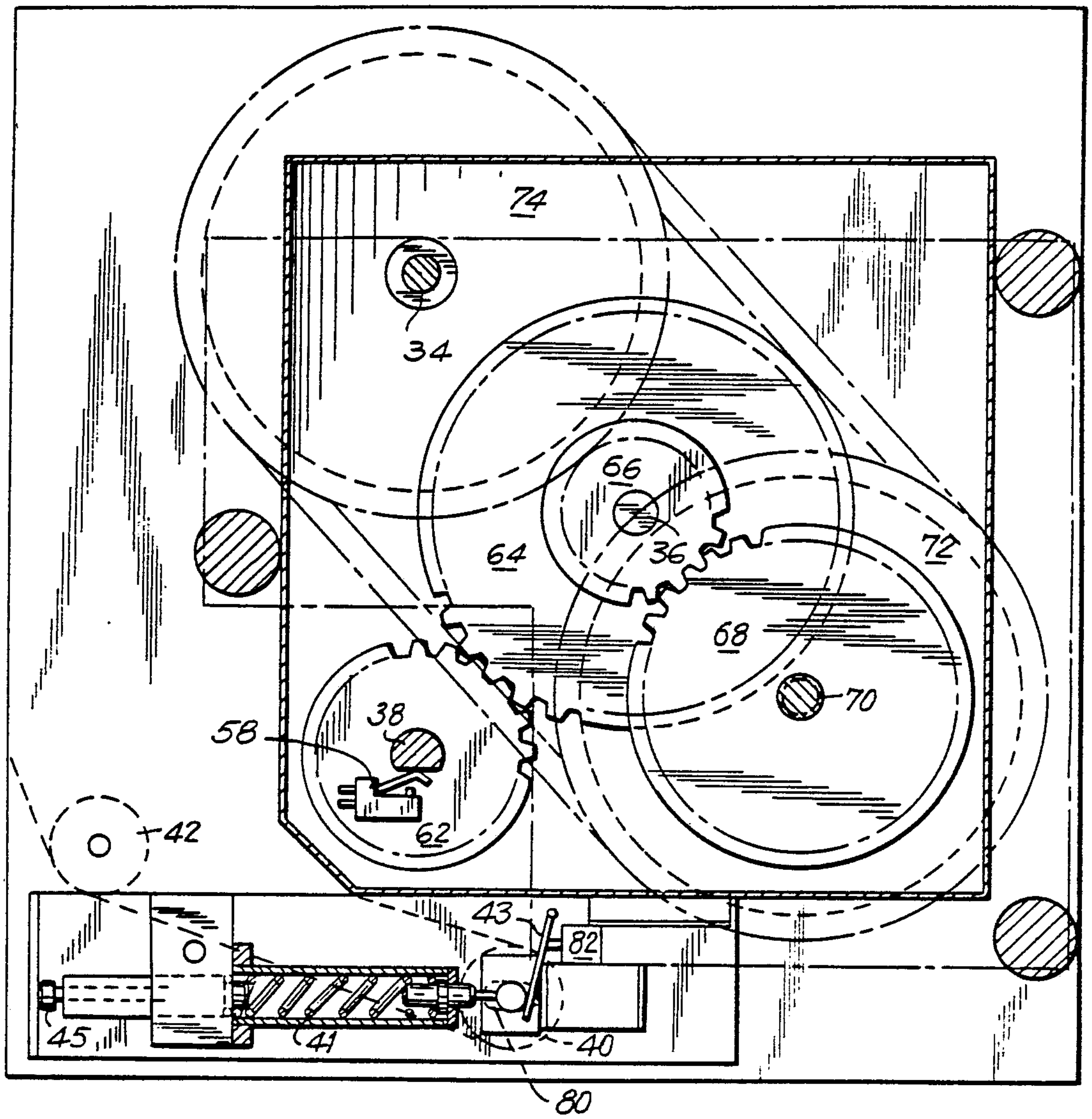
FIG. 1





F/G. 2

FIG. 3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58
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82
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41
40
80

FIG. 4

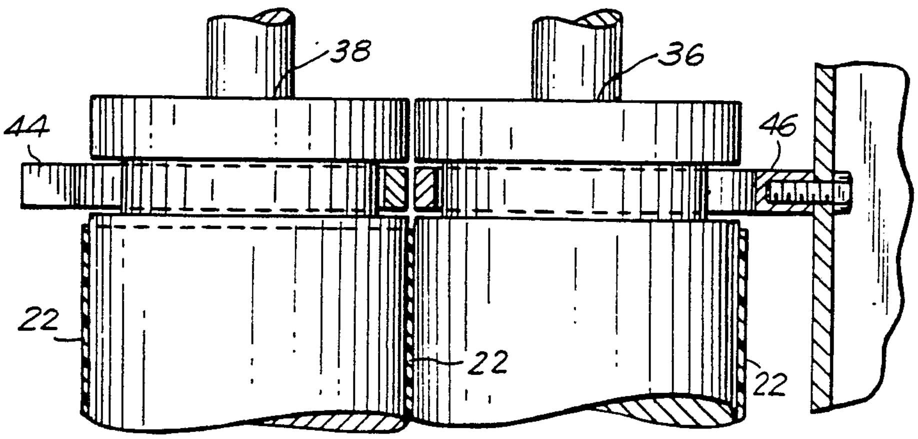
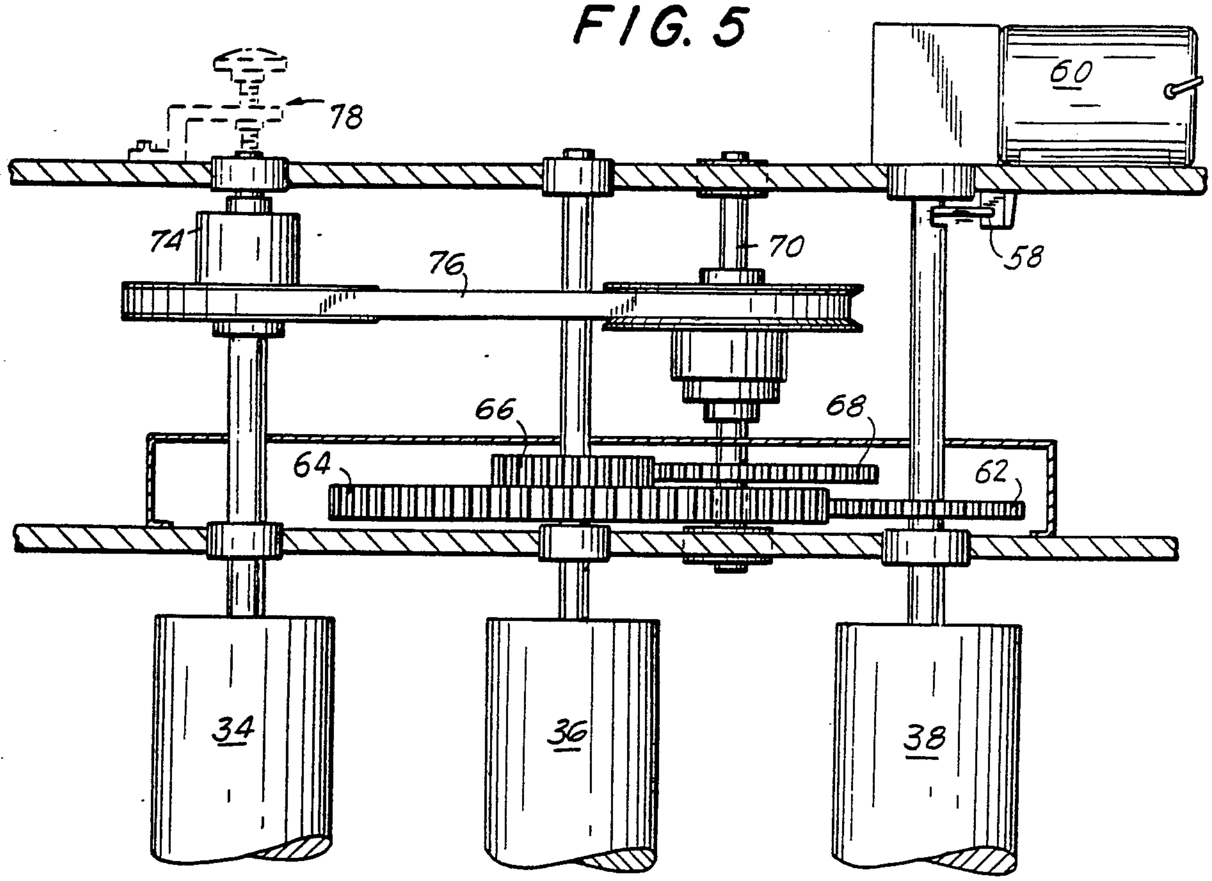

38
36
44
46
22
22
22

FIG. 5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76
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58
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66
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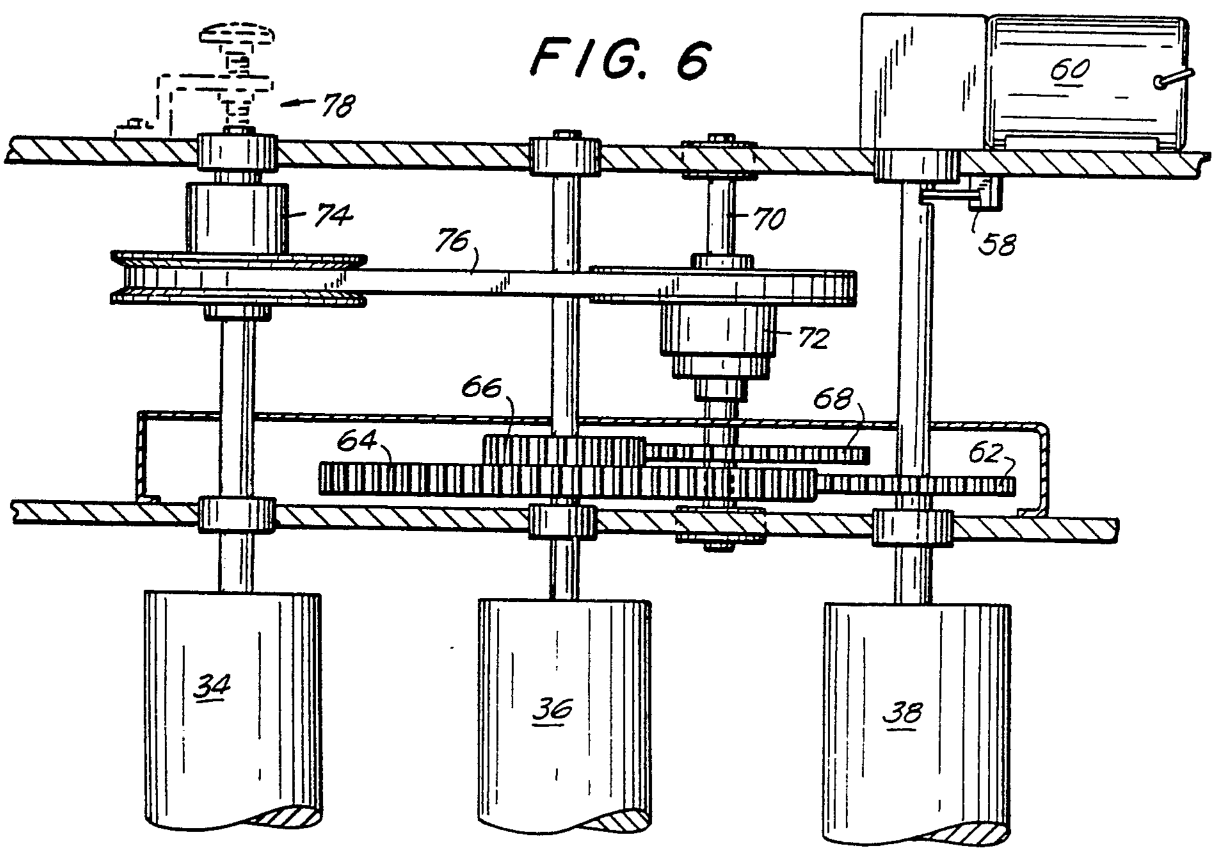
34
36
38

FIG. 6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36
38

FIG. 7

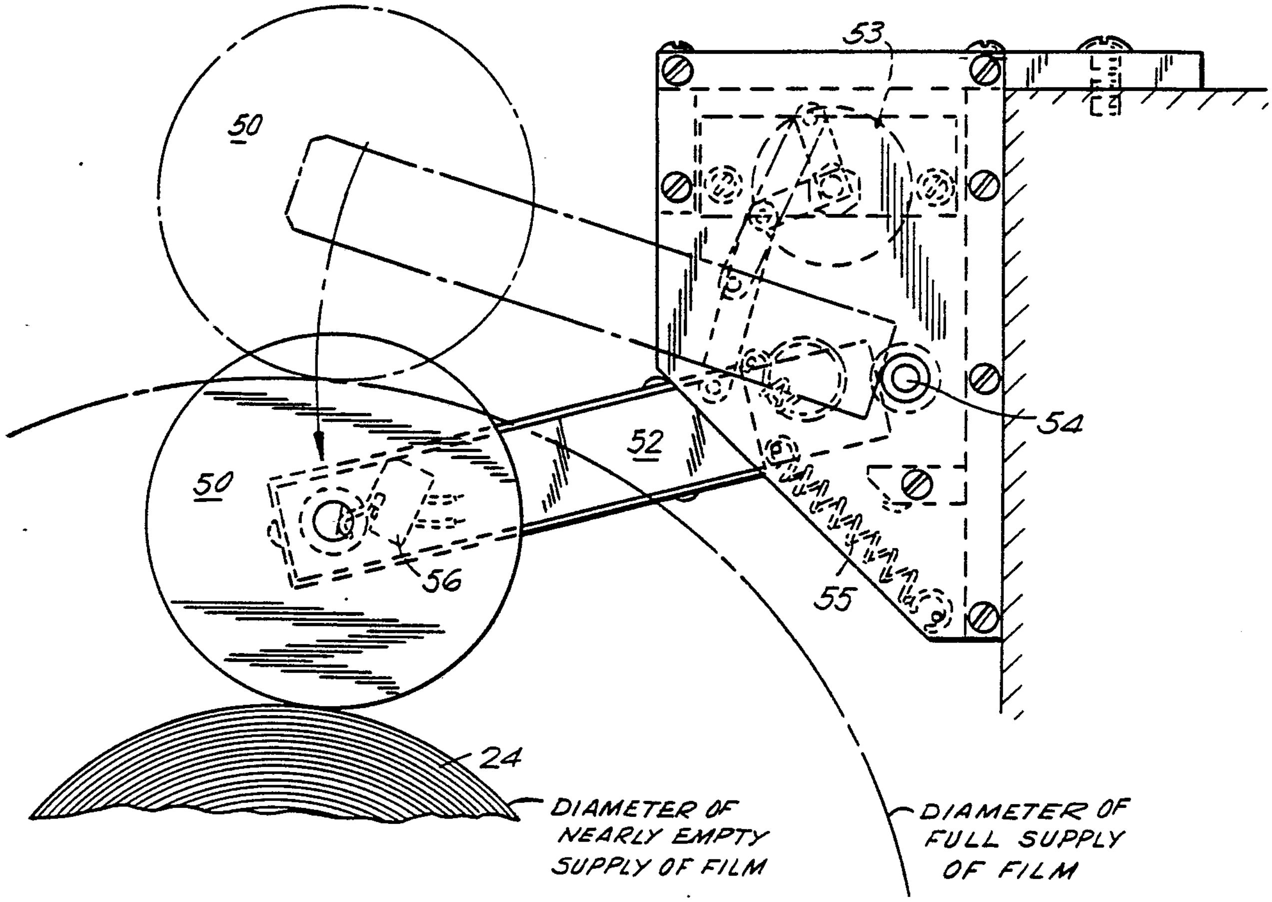
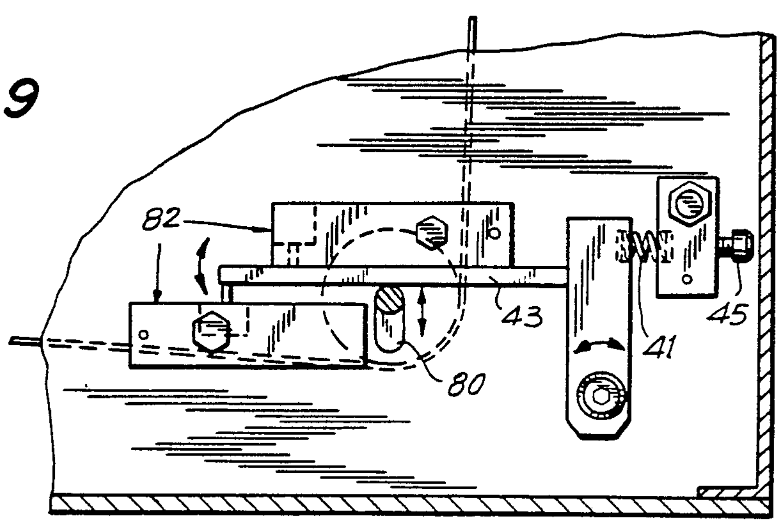

50
53
50
52
54
56
55
24
DIAMETER OF
NEARLY EMPTY
SUPPLY OF FILM
DIAMETER OF
FULL SUPPLY
OF FILM

FIG. 9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80

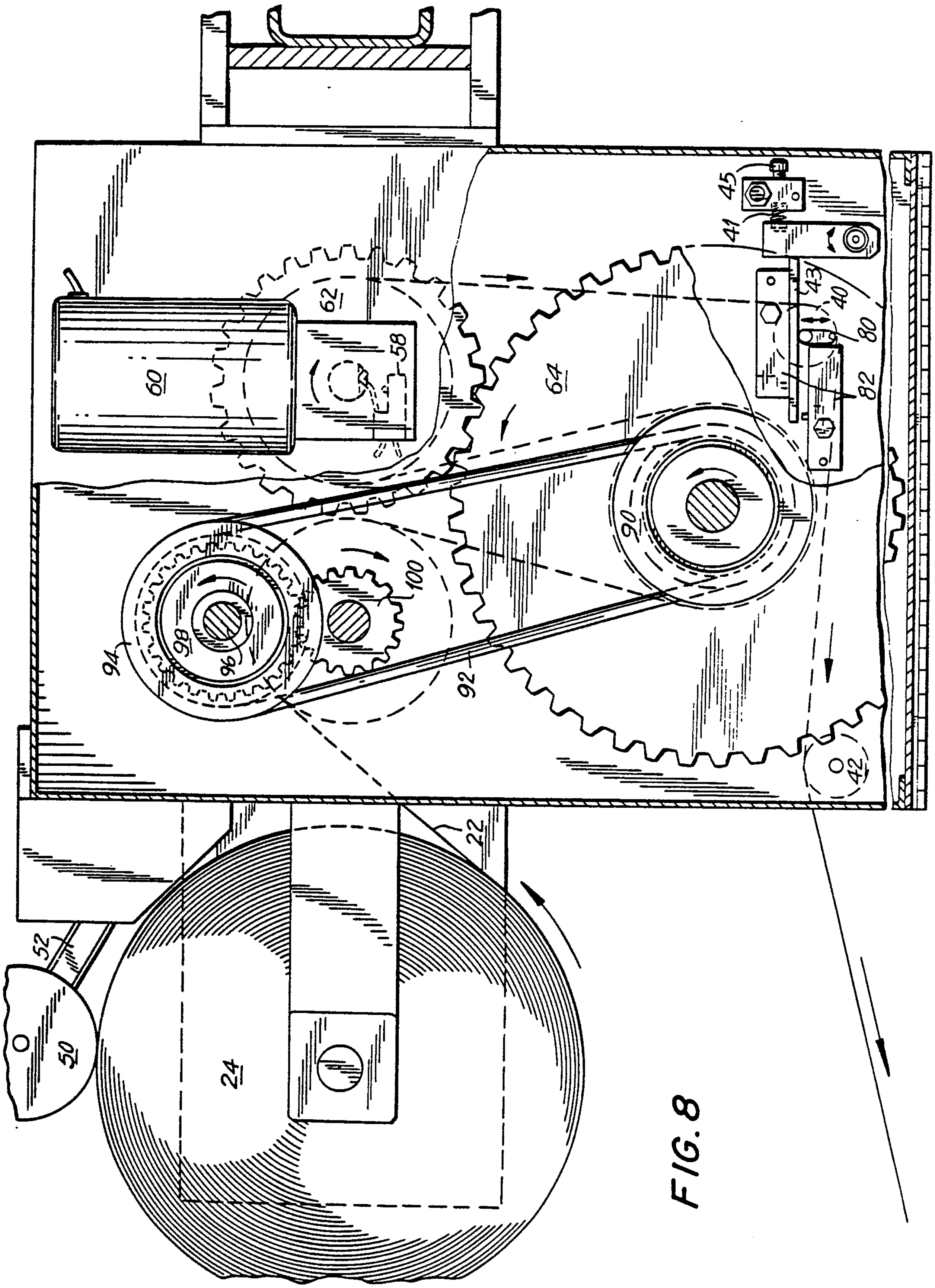
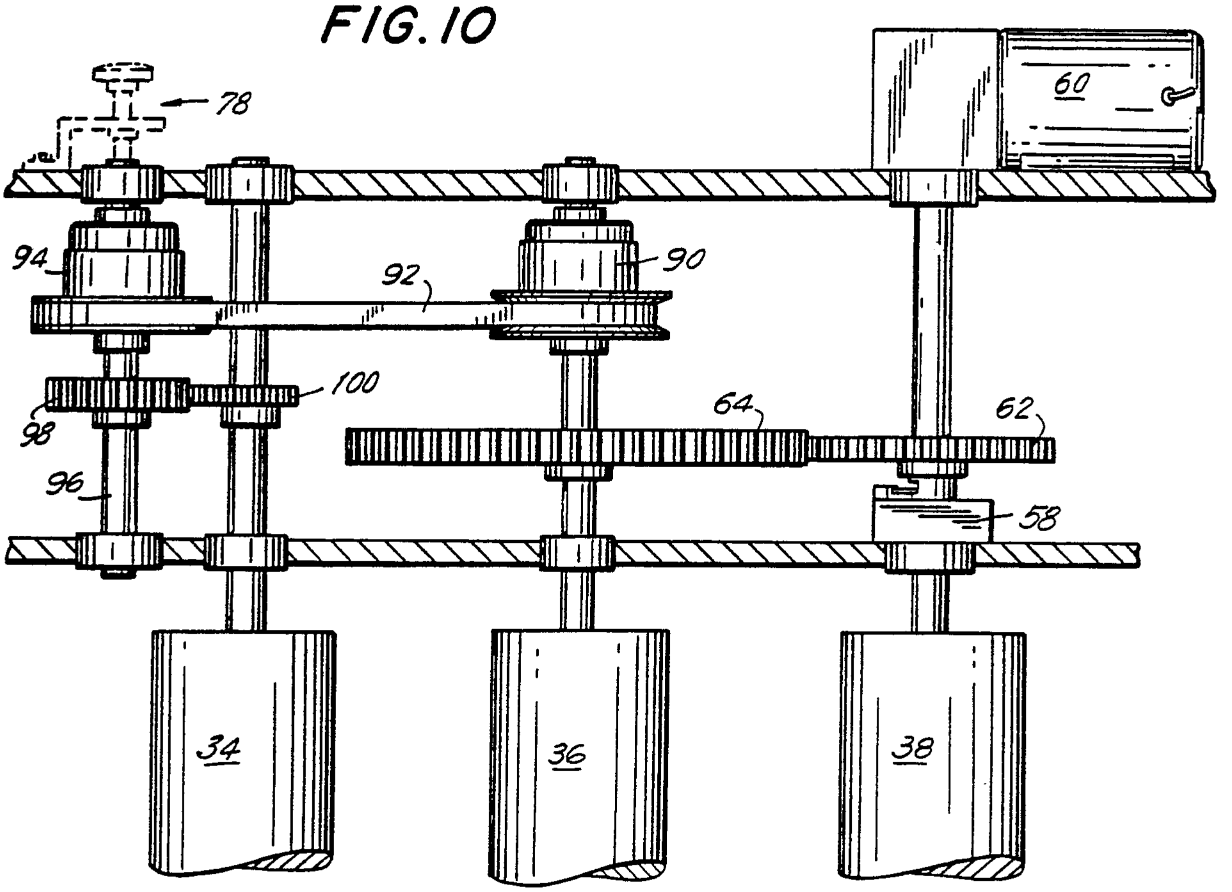


FIG. 8

FIG. 10


78
60
94
92
90
100
98
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62
96
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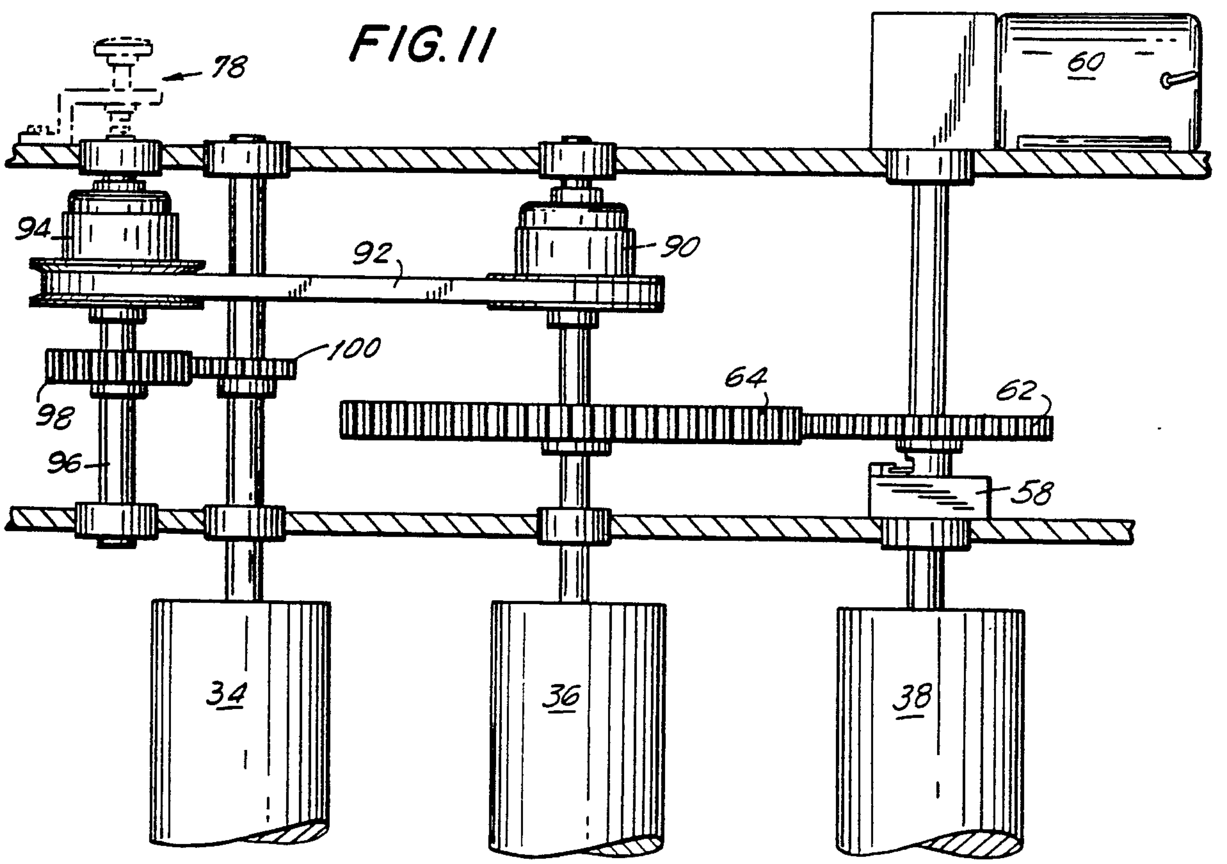
34
36
38

FIG. 11


78
60
94
92
90
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98
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62
96
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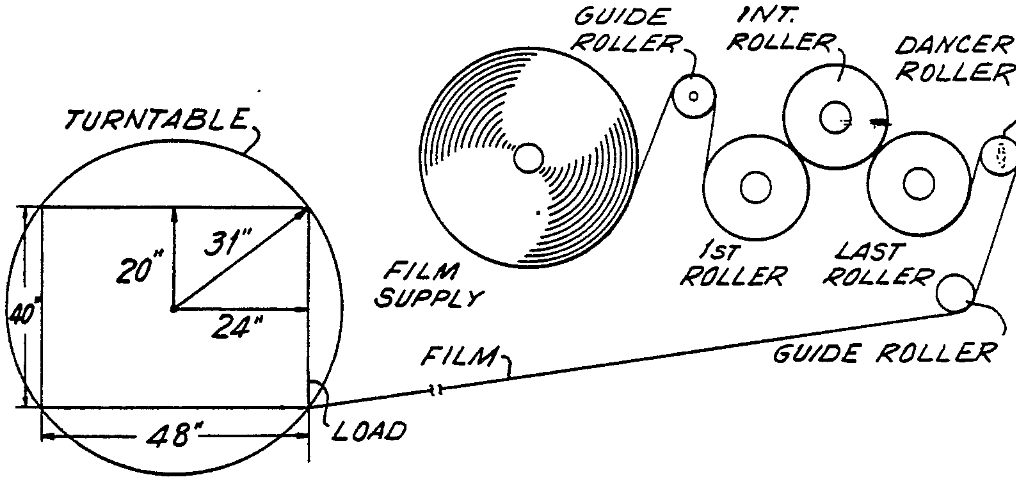
38

FIG. 12



40"x48" LOAD CENTERED ON TURNTABLE

TURNTABLE SPEED 9RPM

LOAD SPEED = CIRCUMFERENCE x

FOR CORNER (1A)

LOAD SPEED = (2) (3.14) (31)(9) = 1752 IN/MIN.

FOR MIDPOINT OF 48" SIDE (2A)

LOAD SPEED =(2) (3.14) (20) (9) = 1130 IN/MIN.

FOR MIDPOINT OF 40" SIDE (3A)

LOAD SPEED = (2) (3.14) (24) (9) = 1356 IN/MIN.

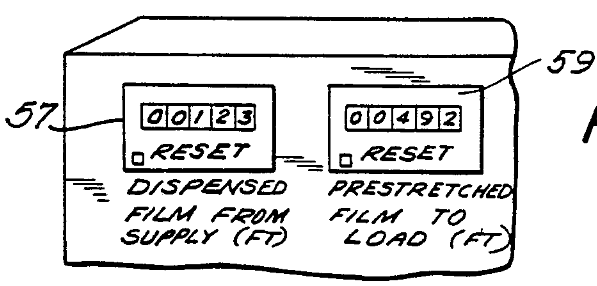


FIG. 13

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 10 7489

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP-A-0 096 635 (PROCTER & GAMBLE) * Page 8, line 24 - page 9, line 26; figure 2 * ---	1,2,4-6	B 65 B 11/04
A	EP-A-0 144 266 (EMCO) * Page 4, line 12 - page 5, line 23; figure 1 * -----	1,6	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 65 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21-08-1987	JAGUSIAK A.H.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document