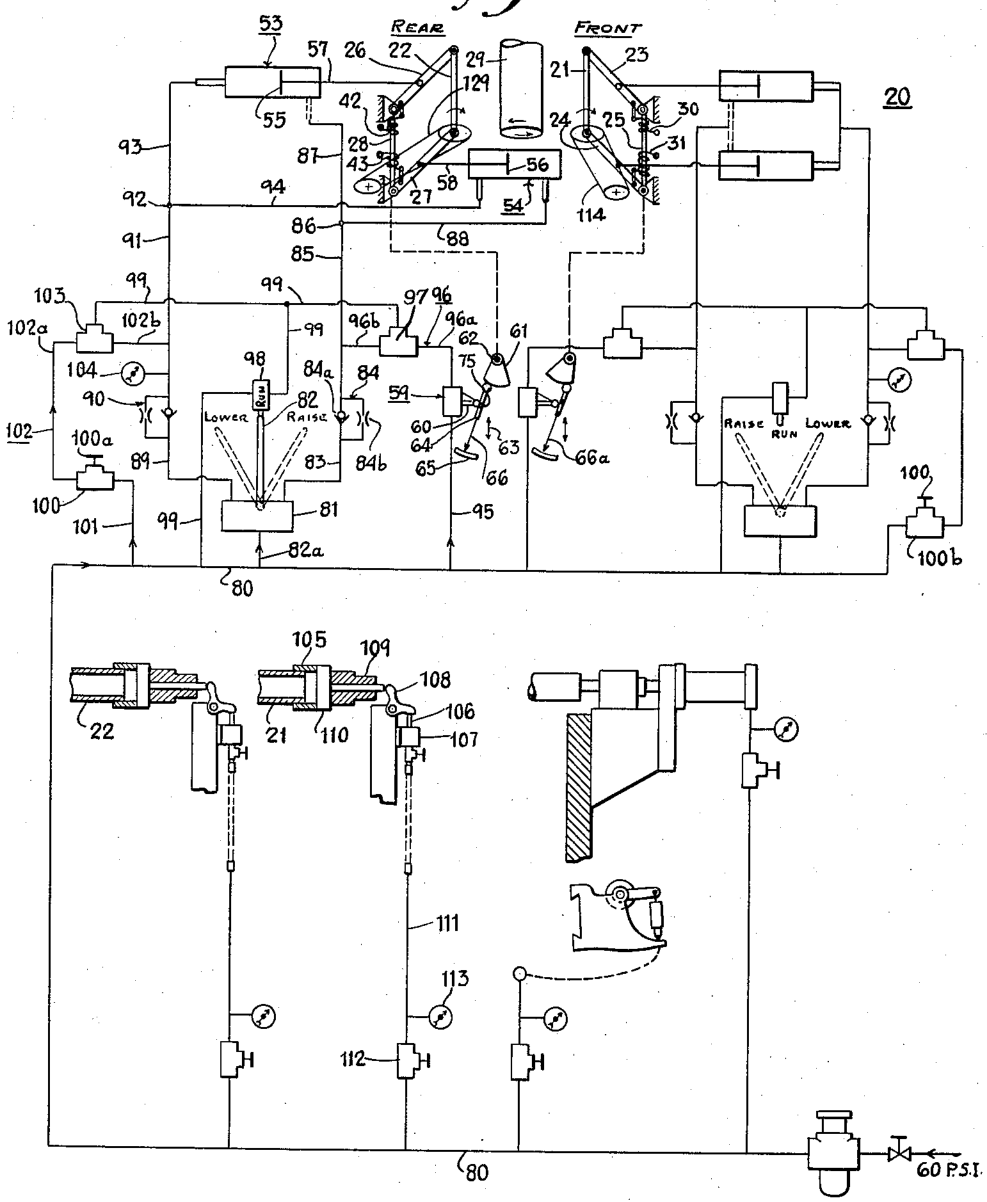
Feb. 3, 1959 L. ROCKSTROM ET AL 2,872,126

REWINDING MACHINE

Filed April 4, 1955 6 Sheets-Sheet 1

Fig. 1.



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REWINDING MACHINE

Filed April 4, 1955 6 Sheets-Sheet 2

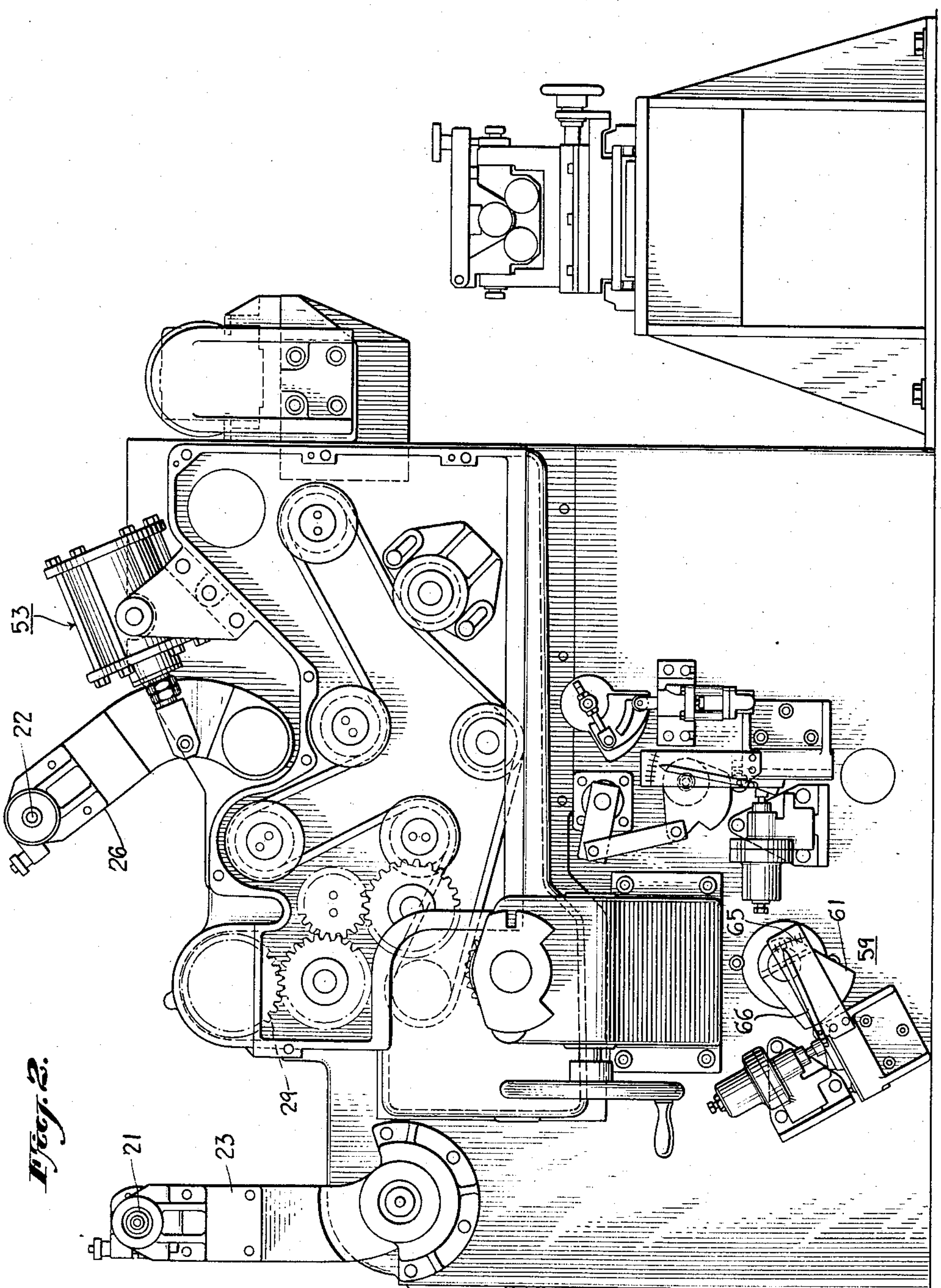

Fig. 2.

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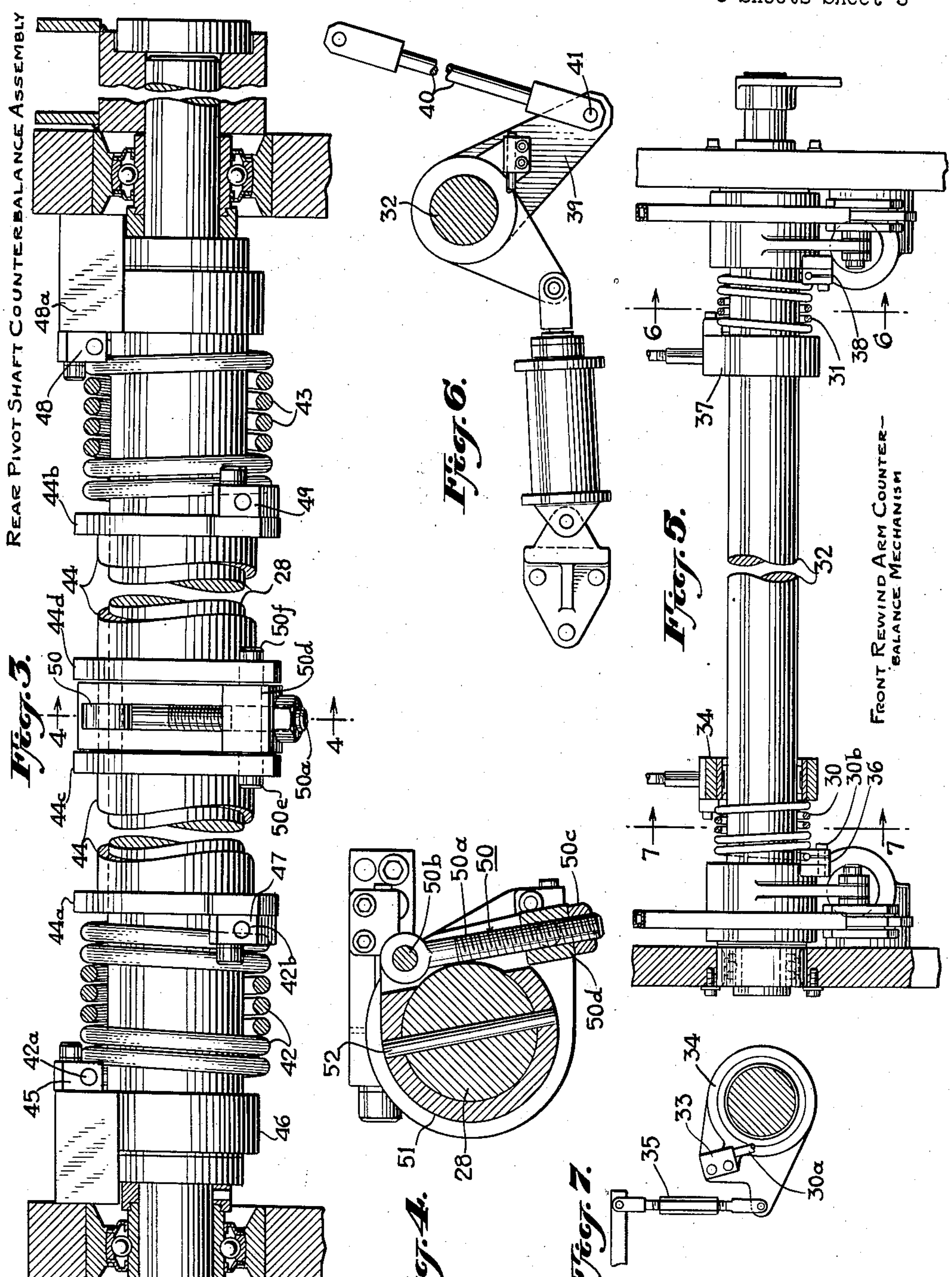
REWINDING MACHINE

Filed April 4, 1955 6 Sheets-Sheet 3



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REWINDING MACHINE

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6 Sheets-Sheet 4

Fig. 8.

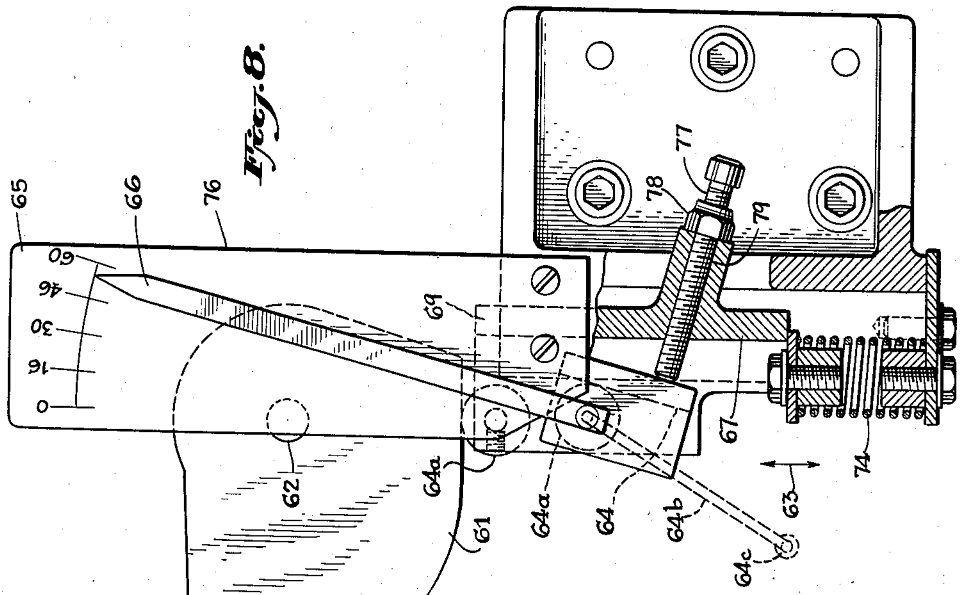


Fig. 9.

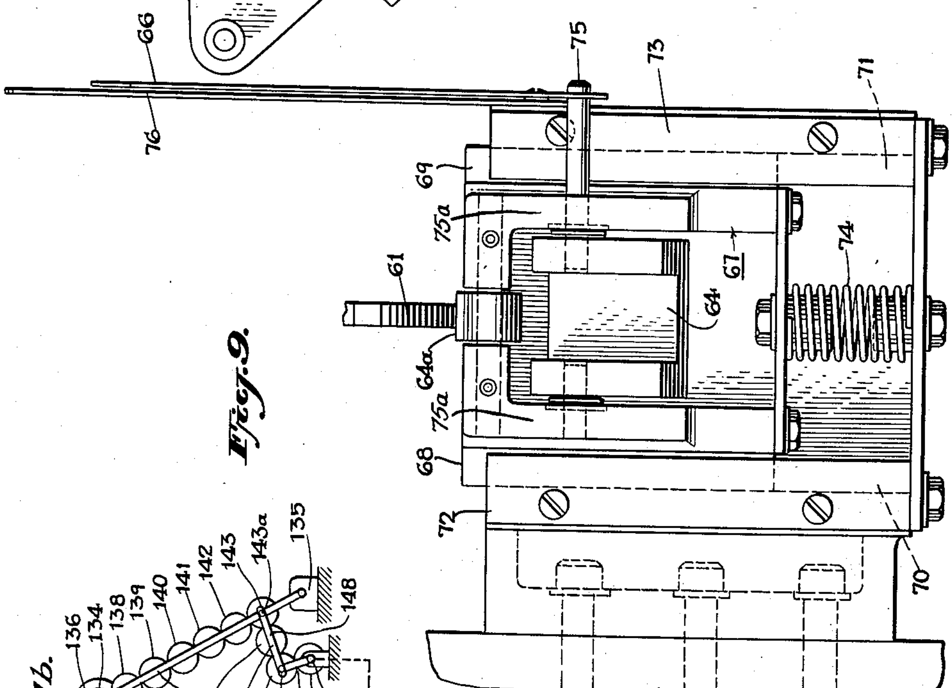
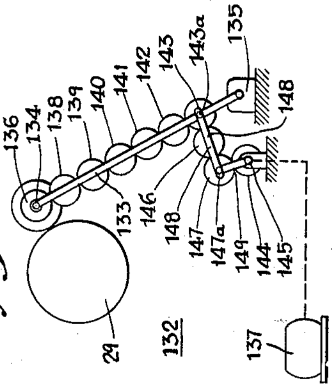


Fig. 11b.



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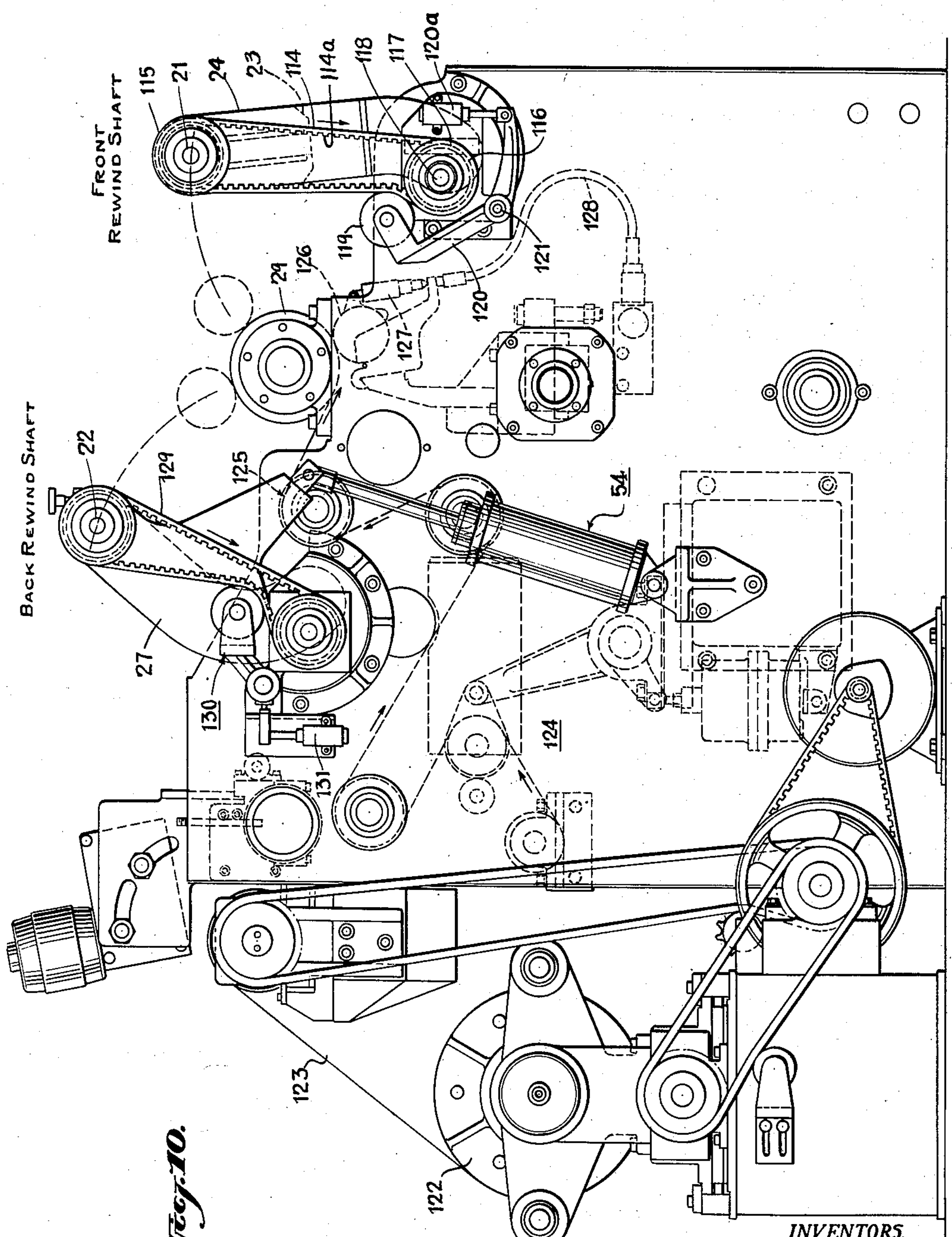

Fig. 10.

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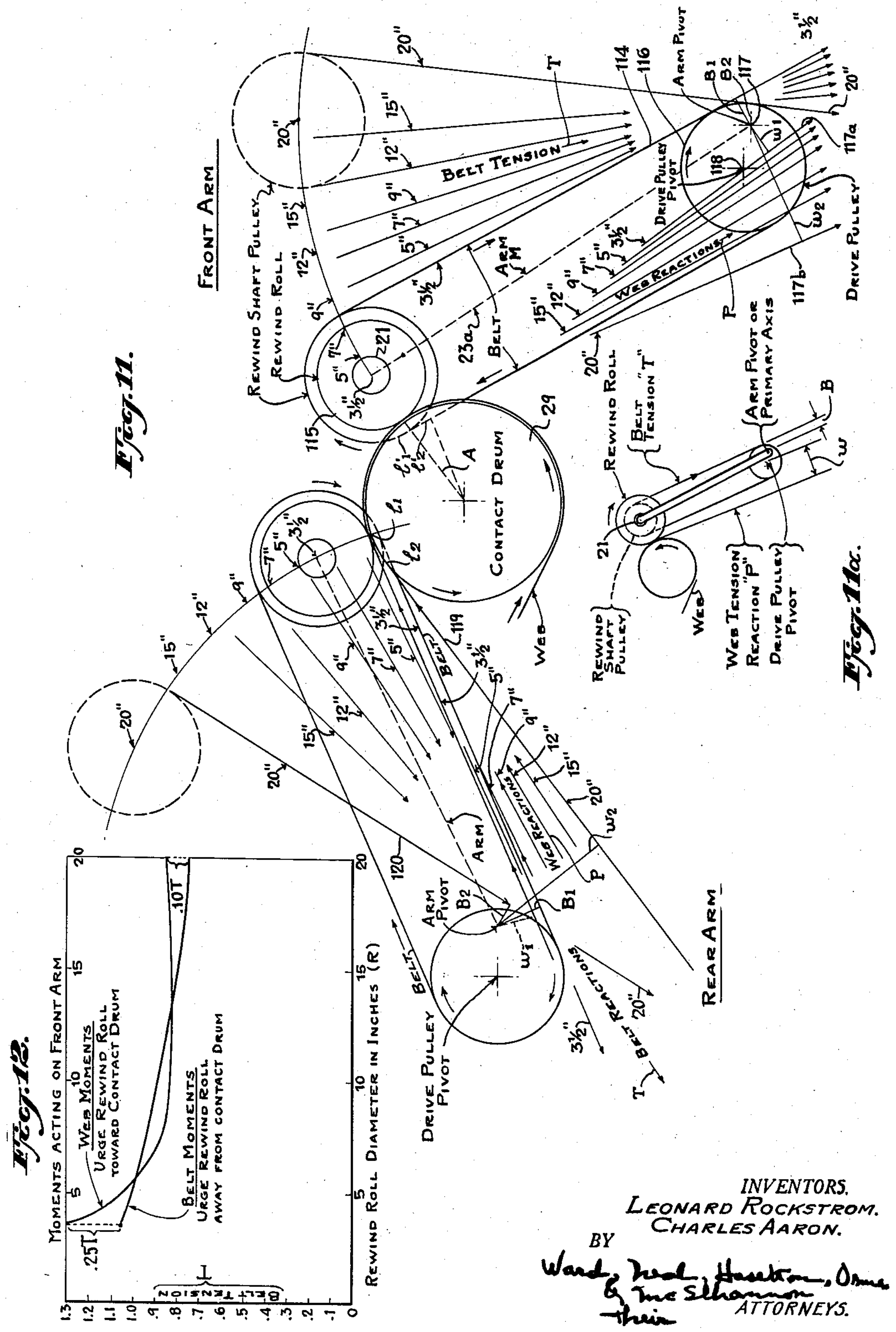

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United States Patent Office

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Patented Feb. 3, 1959

2,872,126

REWINDING MACHINE

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Application April 4, 1955, Serial No. 498,809

14 Claims. (Cl. 242—65)

This invention relates to improvements in rewinding machines, and more particularly to improvements in control means for slitting and rewinding machines.

The invention is shown, by way of illustration, as embodied in a slitting and rewinding machine employing two shafts for supporting two groups of rewound or "rewind" rolls, such a machine being referred to in the art as of the duplex type. However, certain features of the invention are useful in machines of other types.

In the slitting and rewinding of certain types of web material, with particular reference to stretchy materials, usually of plastic, substantial problems have occurred in past apparatus of this character which are attributable to the inability thereof adequately to control the pressures acting on the rewind rolls. That is, the web material which is being slit and rewound in most cases should be subjected to as small contact pressure and tension as is possible commensurate with the requirement to slit and rewind same upon a rewind shaft. Consequently the forces which act upon the web which normally would tend to distort same, must be minimized in order to attain a desired quality of the rewound roll.

It is, of course, important in such machines to attain a high quality control of the rewind rolls, that is, a control of those factors which will provide desired roll density, internal tension and quality of roll edge.

Apparatus of this general type of the prior art have not been capable of adequate controls of such factors, particularly with respect to stretchy materials.

Furthermore, apparatus heretofore proposed have been unable to slit and rewind certain types of web material at high operating speeds, for example, up to 2000 feet per minute.

In slitting and rewinding machines, the mill web passes around a constant speed roll, known as a contact drum, or a platen drum against which the slitters or cutters operate to cut the web into a plurality of smaller rewind widths, although slitting may be done at other locations. These smaller widths pass to the rewind rolls which rest against the driven contact drum, the several rewind rolls being wound upon rewind shafts. Heretofore apparatus of this class has not been able to control adequately the pressure between the rewind rolls and such contact drum nor have such prior art machines been adequately equipped for the purpose of permitting an operator so to control the pressure between the rewind rolls and contact drum, such pressure being herein sometimes referred to as "roll-contact drum pressure" or "contact pressure."

One of the objects of the present invention is to provide novel means for controlling such contact pressure whereby a superior quality control of the end product is attained.

A further object is to provide apparatus of this character which can automatically maintain a minimum uniform rewind roll-contact drum pressure for certain types of material, for example, light stretchy material.

A further object is to provide a sensitive and accurate counterbalance system for apparatus of this type for the

purpose of maintaining the aforementioned minimum uniform contact pressure or rewind roll-contact drum pressure, thereby to produce smooth straight-sided rolls of uniform density, the system being adjustable to provide a heavier contact pressure which also can be uniformly maintained where needed.

Another object is to provide a slitting and rewinding machine which, while operating at heretofore unattained production rates, is capable of providing accurately controlled and desired roll density, internal tension and quality of the side or edge of the rolls.

Still another object is to provide a single apparatus of this character, the versatility of which is such that it is capable of slitting and winding: light, heavy, stretchy or relatively stiff plastics, and laminates of all types, waxed or coated papers, kraft, foil, and impregnated fabrics and other materials.

Another object is to provide an apparatus of this character which can provide easily and completely controllable rewind roll quality wherein there is provided an automatic rewind density control means which is adjustable while the apparatus is running, and wherein the rewind tension is positively isolated from the unwind tension, that is, the web tension in the region of the unwind parent roll and thereby the unwind web tension is prevented from building up in the rewind region of the apparatus.

Still another object is to provide an apparatus of this character wherein roll density can be controlled automatically with high precision between substantial limits whereby the rolls can be either of soft or hard consistency.

Still a further object is to provide novel means for automatically balancing the torque which acts upon the supporting arms for the rewind shaft, such torque being due to the pull of the web being wound upon such shaft.

Another object is to provide novel counterbalancing means for automatically counterbalancing the static weight of the web material as it builds up in the rewind rolls.

And still a further object is to provide novel means for counterbalancing the dead or static weight of the supporting arms for the rewind roll or rolls, including the static weight of the rewind shaft structure.

Further objects and advantages of the invention will more fully appear from the following description taken in connection with the accompanying drawings which show, by way of example, the present preferred form of the invention.

Referring to the accompanying drawings, in which the same reference characters indicate the same parts in the various views:

Fig. 1 is a schematic diagram illustrating one form of apparatus embodying the present invention with particular reference to the interconnections for a pneumatic system employed thereby;

Fig. 2 is a side elevation of one form of apparatus embodying the present invention and in particular illustrating the rewind rolls and their supporting shafts in association with cam control means which in turn govern pneumatic counterbalancing means for counterbalancing the static weight of the rewind rolls as they build up in diameter;

Fig. 3 is a front elevation of the rear pivot shaft to which is secured two supporting arms for the rear rewind shaft, such figure illustrating certain coil spring means employed for counterbalancing the static weight of such arms and rewind shaft;

Fig. 4 is a sectional view taken substantially on line 4—4 of Fig. 3;

Fig. 5 is a front elevation of a counterbalancing mechanism for the front rewind arms and front rewind shaft employed in the apparatus and shows a pair of coil springs wound about a central shaft for this purpose;

Fig. 6 is a sectional view taken substantially on line 6—6 of Fig. 5;

Fig. 7 is a sectional view taken substantially along line 7—7 of Fig. 5;

Fig. 8 is a side view of a rewind roll counterbalance valve means employed in the invention, including a sliding cam device which is adjustable in terms of the number of inches of the width of the web material wound on the pertinent rewind shaft;

Fig. 9 is a front elevation of the parts shown in Fig. 8;

Fig. 10 is a side elevation of the novel apparatus showing the latter on the opposite side thereof with respect to that shown in Fig. 2 and in particular illustrating an offset drive pulley construction wherein the axis of each of the respective drive pulleys for the respective rewind shafts is offset with respect to the pivot axis of its respective rewind arms, for the purpose of counterbalancing the pull of the web acting upon the respective supporting arms;

Fig. 11 is a schematic view on a somewhat enlarged scale as compared to Fig. 10 and illustrating in greater detail the offset of the axis of the drive pulley for each rewind shaft with respect to the pivot axis of the supporting arms for such shaft and also illustrating schematically the several moment arms and moments which are created in the counterbalancing of the web pull;

Fig. 11*a* is a schematic showing of certain parts of Fig. 11 in an intermediate position and also illustrating schematically certain of the moments and moment arms instantaneously occurring; and

Fig. 11*b* is a schematic showing in side elevation of counterbalancing means which performs a function analogous to that of the means shown in Fig. 11.

Fig. 12 is a graphical showing of the relationship of two of the opposing moments which act about the axis of the front rewind roll supporting arms.

Referring to the drawings in greater detail, there will now be described in general and briefly the operation and construction of the apparatus whereupon the details of the several counterbalancing systems will be described at greater length.

Referring to Fig. 1, the apparatus comprises a slitting and rewind device generally designated **20** which includes a pair of rewind shafts **21** and **22** which are respectively the front and rear rewind shafts. The front rewind shaft is supported by a pair of rewind arms **23** and **24** which at the inner ends thereof, that is, the lower ends as viewed in this figure, are mounted for angular movement about a fixed or primary axis, such inner ends of the arms thus being mounted upon a pivot shaft **25** which is journaled for angular movement in the frame of the apparatus.

The rewind shaft **22** in turn is supported by a pair of rewind arms **26** and **27** which, at the inner ends thereof, are mounted upon a pivot shaft **28** which also is mounted for angular movement in suitable journals in the frame of the apparatus whereby said rewind arms **26** and **27** also are adapted for angular movement about a primary axis, namely, that of the shaft **28**.

The shafts **21** and **22** are shown in raised or spaced relationship with respect to a contact drum **29**, partially about which there passes the web material which is slit and thereafter wound into rolls upon the rewind shafts **21** and **22**.

The slitting devices, comprising a plurality of wheel-like knives for pressing against the contact drum **29**, are briefly described hereinafter but are not a part of this invention.

The contact drum **29**, as aforementioned, is driven at a constant speed by any suitable means (not shown) and the rewind shafts **21** and **22** are driven at variable speeds, which speeds decrease as the rewind roll diameter increases. The drive and speed control means for said drum **29** and shafts **21** and **22** may be similar to that shown and described in U. S. Patent No. 2,650,039, granted August 25, 1953, to Thomas N. Carter.

There will now be described the several counterbalancing systems which are designed respectively for counterbalancing: the static weight of the rewind arms and shafts, the static weight of the rewind rolls as the rewind diameters build up upon the rewind shafts, and the pull of the web upon the rewind arms or rewind shafts. The torques effected by such weights and the web pull act about the primary axis of each of the aforedescribed pairs of rewind arms.

System for counterbalancing the static weight of the rewind shaft support arms and rewind shafts

Referring now particularly to Figs. 1 and 3–7, inclusive, it will be observed that in Fig. 1 there is schematically shown a pair of coil springs **30**, **31** which respectively are coiled about the front pivot shaft **25**. Such coil springs at the inner extremities thereof are relatively fixed whereas the outer extremities thereof are secured to the respective rewind shaft support arms **23**, **24** in such a manner that as such support arms shift angularly in a counterclockwise direction towards the contact drum **29**, the coils thereof are "wound up" thereby increasing the force exerted upon the support arms **23**, **24** to counterbalance the static weight thereof, together with the weight of the rewind shafts **21**.

In greater detail such springs **30** and **31** are shown in Figs. 5 and 7. However, in view of the fact that Fig. 1 is a schematic showing, the springs **30** and **31** have been shown coiled directly about the pivot shaft **25**, whereas in Fig. 5 the springs **30** and **31** are not coiled directly about the pivot shaft **25** but in lieu thereof are coiled about another shaft of this counterbalance mechanism designated **32**, which in fact is situated below the pivot shaft **25** but is operatively connected thereto by means of a suitable linkage whereby the torque of the springs **30** and **31** is communicated to the pivot shaft **25** and thence to the arms **23** and **24**.

As is well shown in Fig. 7, an innermost extremity **30*a*** of the spring **30** is rigidly secured in a clamp **33** of a spring collar **34** which, by means of a fixed but adjustable arm **35**, is prevented from shifting angularly thereby anchoring the aforementioned spring extremity **30*a***. The opposite extremity of the spring **30** at **30*b*** (Fig. 5) is rigidly secured to the shaft **32** by means of a clamp **36** which is analogous to the clamp **33**.

The opposite extremities of the spring **31** are analogously secured to a spring collar, such as **37**, analogous to collar **34**, and to a clamp **38** which is analogous to the clamp **36**.

The aforementioned linkage which operatively interconnects the shaft **32** to the pivot shaft **25** is partially shown in Fig. 6 and comprises a lever arm **39** and a rod **40** which is pivoted at **41** to one extremity of the lever arm **39**, the opposite extremity of the rod **40** being pivotally secured to another lever arm (not shown) which in turn is attached suitably to the pivot shaft **25**.

Referring now to Fig. 3, the counterbalance system for the rear shaft will be described which differs somewhat from that of Fig. 5 by virtue of the fact that the two opposite counterbalance coil springs **42** and **43** are associated at the inner ends thereof by means of two spring control sleeves **44** which are similar but of opposite hand. The spring **42** is operatively connected to the system as follows: The outer extremity thereof at **42*a*** is secured by means of a clamp **45** to a collar **46** which is secured to the frame of the apparatus, whereas outer extremity **42*b*** of the spring **42** is secured by means of a spring clamp **47** to a flange **44*a*** of the lefthand sleeve **44**. Analogously the opposite extremities of spring **43** are secured respectively by means of spring clamps **48** and **49** to a stationary collar **48*a*** (secured to the frame) and a flange **44*b*** of the righthand sleeve **44** (Fig. 3).

The two sleeves 44 can be angularly adjusted about the pivot shaft 28 by means of an adjustable ring device generally shown at 50 consisting of a ring portion 51 which is rigidly secured against angular shifting upon the shaft 28 by means of a pin 52 (Fig. 4). A threaded bolt 50*a* is pivotally secured at 50*b* to the ring portion 51. By means of a threaded nut 50*c*, which engages the bolt 50*a*, inner flanges 44*c* and 44*d*, respectively secured to said two sleeve members 44, are caused to shift angularly within selected limits. This is accomplished by means of an adjustment lug 50*d* having a bore through which passes the aforementioned bolt 50*a* and which further is provided with trunnions 50*e* and 50*f* which respectively engage suitable bores in the sleeve flanges 44*c* and 44*d*. Thus by adjustment of the nut 50*c*, a suitable adjustment of the coils 42 and 43 can be effected.

Thus as the rear rewind shaft supporting arms move in a clockwise direction, as viewed in Fig. 1, the springs 42 and 43 will be adequately coiled to counterbalance the moment thereon effected by gravity acting said arms 26 and 27 and the rewind shaft 22, such moment, of course, being a varying one and a gradually increasing one as such arms move from their raised position toward the contact drum 29.

System for counterbalancing increasing web material weight on the rewind rolls

Referring now to Figs. 1, 2, 8 and 9, the counterbalancing system will now be described for compensating for or counterbalancing the increasing static weight of the web material as it builds up on the rewind shafts 21 and 22.

We have found it desirable to counterbalance the aforementioned gradually increasing web material weight by means of a pneumatic pressure device which exerts gradually increasing pressure upon the supporting arms for the rewind rolls in response to angular movement of such supporting arms from a selected norm position, the latter position, of course, referring to the position of the arms at the minimum rewind roll diameter which occurs at the outset of the rewind operation.

Further we have found it desirable, in order to insure that an equal counterbalancing moment is exerted upon both of the supporting arms of each pair thereof, to employ two pairs of pneumatic power devices, one for each arm and in Fig. 1 it will be noted thus that four such pneumatic power devices are employed. This counterbalancing system will be described with respect to the rear rewind shaft supporting arms 26, 27, it being understood, of course, that an analogous apparatus is employed for the front rewind shaft supporting arms 23, 24.

The pair of power devices for such rear shaft, in the form shown, comprise pneumatic power cylinders respectively designated 53 and 54 which are respectively drivably connected with the support arms 26 and 27. The pneumatic devices 53 and 54 are respectively provided with pistons 55 and 56 which are interconnected with their supporting arms 26 and 27 by means of piston rods 57 and 58.

Fluid under pressure, preferably air, is directed to the power cylinders 53 and 54 under the influence of a control valve 59 which in turn is under the influence of two different factors: (*a*) the angular position of the arms 26 and 27; and (*b*) the sum in inches of the rewind roll widths on the given rewind shaft, that is, the weight of the rewind rolls in terms of the widths thereof.

Regarding the latter factor, it comprises a prorated share of the weight of the parent roll which is wound upon the rewind shaft. That is, the total weight of a parent roll, for example, of sixty inches in width, is known and if the slitters are so adjusted, for example, to rewind a total of thirty inches of such width of the parent roll upon a rewind shaft, then the latter factor (*b*) is adjusted in such a way that it reflects the rewinding of thirty inches of the parent roll.

Alternatively, the total weight of the parent roll need not be known. However, the adjustment for the factor (*b*) above mentioned is made upon the apparatus, as will be set forth below, for both the front and the rear rewind shafts in such a way that both adjustments reflect the total width of the parent roll in inches (or whatever suitable term is desired) and consequently an adequate adjustment is made for the prorated share of the parent roll which is ultimately to be wound upon the rewind shaft.

Consequently, referring to Fig. 1, the valve 59, by means of a control rod 60, is placed under the influence of a control cam 61 which is angularly shiftable in response to angular movement of the support arms 26, 27, such cam being suitably operatively interconnected thereto, for example, to the pertinent pivot shaft 28.

The cam 61, by angularly shifting upon its axis 62, is capable of shifting, in the direction of the arrow 63, a ramp element 64 which is adjusted in slope in response to the aforementioned factor (*b*) in accordance with the "sum of the rewind roll widths in inches," reference being had for this purpose to a suitably graduated scale at 65, the adjustment being made with the aid of a pointer 66.

The aforementioned ramp element 64 is retricted to move in the direction of the arrow 63 by a carriage 67 which, as is well shown in Fig. 9, is restricted in movement in a vertical direction by means of guides 68 and 69 which move in vertical grooves 70 and 71, respectively, which are formed in stationary guideposts 72 and 73, respectively.

In the form shown, the carriage 67 is urged upwardly by means of a coil spring 74 (Fig. 9) which provides the driving power for the carriage 67 and hence for the ramp 64, the angular movement of the cam 61 distorting the spring 74 in response to the angular position of the support arms 26, 27.

The ramp 64 thus can be adjusted in its angular position about an adjustment shaft 75 thereby to control the slope of such ramp and hence to superimpose the correction or compensating factor for the sum of the rewind roll widths upon the correction factor for the angle of movement of the support shafts 26, 27. Shaft 75 is mounted for angular movement upon arms 75*a* of the carriage 67.

A cam follower 64*a* (Fig. 8) in the form of a roller rides upon the ramp 64, such follower being mounted for rotation upon an arm 64*b* which is angularly shiftable about a fixed pivot 64*c*. The roller 64*a* is coaxial with shaft 75 when cam 61 is in its zero or "no correction" position.

The shaft 75 which supports the ramp 64 can be frictionally held in a desired angular position after it has been suitably adjusted by well known clamp means. As is well shown in Fig. 8, the graduations 65 are formed upon a suitable plate 76 which may be secured to the guidepost 73.

It will be seen that there is provided for the ramp element 64 an adjustment screw 77 having a lock nut 78 therefor, the screw 77 passing through a suitable threaded bore 79 formed in the movable carriage 67 of the ramp element 64.

The fluid pressure, which is under the influence of the control valve 59, is directed to both of the pneumatic cylinders 53 and 54 in a manner to be more fully described herebelow.

Prior to describing the interconnection of the valve 59 with the fluid conduit system for the pneumatic power devices 53 and 54, there will be described the conduit system for conducting fluid under pressure to such pneumatic cylinders for the purpose of raising and lowering the rewind shaft 22. Thereafer the interconnection of such conduit system to the valve 59 will be described.

Fluid, such as air under pressure, is obtained from a main fluid pressure line 80 which, for example, may contain air under pressure of 60 p. s. i. Such air under pressure is conducted to the pneumatic cylinders 53 and 54 for the purpose of either raising or lowering the rewind shaft 22 by means of a four-way main valve 81 which is controlled by means of a hand lever 82, the latter being adjustable in position to the position shown in broken lines respectively at the right and left for "raise" and "lower," or alternatively to a central position, as shown in solid lines for "run" as will appear more fully hereinafter.

The main valve 81 is interconnected to the conduit 80 by means of a conduit 82*a*, and is respectively connected to the "raise" sides of the pneumatic cylinders 53 and 54 by means of a conduit 83 which is directed to a check valve 84, the latter having a bypass restriction. As is schematically shown in Fig. 1, the check valve 84 is provided with a ball check 84*a* which will permit the passage of air towards the cylinders 53 and 54 but not away therefrom, and is also provided with a bypass restriction 84*b* for a purpose that will appear hereinafter. The check valve 84, by means of a conduit 85, in turn is connected to a conduit junction 86 from which emanate conduits 87 and 88 respectively connected to the "raise" sides of the pneumatic cylinders 53 and 54. That is, the conduits 87 and 88 are connected to the cylinder chambers which are in Fig. 1 to the right of the pistons 55 and 56 and thus on the side thereof to which fluid is directed for the purpose of raising the support arms 26, 27.

The main valve 81 is connected to the "lower" sides of the aforementioned cylinders 53 and 54 by an analogous conduit system as follows:

A conduit 89 interconnects the main valve 81 to a check valve 90 having a ball check device and a bypass restriction therein analogous to 84*a* and 84*b*, that is, fluid is permitted to pass toward the pneumatic cylinders, not away therefrom, by such ball check and the bypass restriction is provided therein also for a purpose to appear hereinafter.

The check valve 90 is in turn, by means of a conduit 91, connected to a conduit junction 92 which is respectively connected to the pneumatic cylinders 53 and 54 by means of conduits 93 and 94, the latter conduits being connected to the aforementioned "lower" sides of their respective cylinders.

Thus when it is desired to raise the rewind shaft 22, the main valve handle 82 is moved to the righthand position (Fig. 1) which conducts fluid to the cylinders 53 and 54 by means of the following path: conduit 82*a*, valve 81, conduit 83, check valve 84, conduit 85 and the conduits 87 and 88. The air under pressure thus urges the pistons 55 and 56 to the left, as shown in Fig. 1, thereby raising the support arms 26, 27. This pressure is prevented from slamming the support arms 26, 27 against their limit-stops (not shown) by means of the back pressure existing in the lefthand chambers of said cylinders which escapes via the following path: conduits 93, 94, conduit 91, the check valve 90 (via the bypass restriction therein), the conduit 89 and an exhaust port in the main valve 81.

When the support arms 26 and 27 are in their raised position and it is desired to lower same to an operating position adjacent the contact drum 29, the handle 82 is shifted from its righthand or raise position to its lefthand or lower position, as shown in Fig. 1, thereby directing air under pressure to the lefthand chambers of the cylinders 53, 54 via the following path: 82*a*, 81, 89, 90, 91 and 93, 94. The support arms 26, 27 are again prevented from slamming against their lower limit-stops (not shown) by means of an analogous air cusioning which is bled from the righthand chambers of their respective cylinders via the bypass restriction 84*b* of the check valve 84 and a suitable exhaust port in the main valve 81.

The interconnection of the cam controlled valve 59 into the aforementioned conduit system will now be described. The cam controlled valve 59 is connected to the main air conduit 80 by means of a conduit 95 and is on the opposite side thereof connected to the conduit 85 by means of a conduit 96, there being interposed in the latter conduit a pressure-operated poppet valve 97 which serves the purpose of isolating the cam control valve 59 whenever the handle 82 is moved away from the aforementioned central or "run" position.

The conduit 96 is divided into two portions, namely, 96*a*, which interconnects the valve 59 to the poppet valve 97, and a portion 96*b* which interconnects said valve 97 to the conduit 85. When the poppet valve 97 is actuated, it blocks off the conduit 96*a*, thereby preventing the leakage of fluid via such conduit 96*a*.

The poppet valve 97 is opened by a suitable pilot valve 98 which is responsive to the plating of the handle 82 in the central position, as shown in Fig. 1 in solid lines.

The poppet valve 97 is closed when the handle 82 is in either the raise or lower position by virtue of fluid under pressure conducted thereto via a conduit 99 in which the pilot valve 98 is interposed. Thus the aforementioned cam controlled valve 59 is isolated from the fluid infeed system when the handle 82 is in said "raise" or "lower" position.

However, when the handle 82 is placed in the center or "run" position, the pilot valve 98 is actuated in such a way that the pressure normally acting upon the poppet valve 97 is bled therefrom and the fluid under pressure from conduits 95, 96 is allowed to pass to the cylinders 53, 54 via the cam control valve 59, the poppet valve 97 then being open.

It is, of course, understood that the main valve 81 is in a closed condition when the handle 82 is in the central position thereby insuring that the full fluid pressure in conduits 95, 96 suffers no leakage and is directed to the pistons 53, 54.

When the fluid pressure is so directed to the cylinders 53, 54 via the cam controlled valve 59, we have found it desirable to introduce a so-called "in-pressure," that is, a pressure acting counter to the fluid pressure coming via the cam controlled valve 59, the purpose for this being to provide a more positive control of the fluid pressure counterbalancing system to provide a precision control of the aforementioned contact pressure, that is, the pressure of the rewind roll against the contact drum 29.

Accordingly, a hand controlled "in-pressure" regulating valve 100 is provided for controlling the flow of air under pressure to the lefthand chambers of the cylinders 53, 54. Such "in-pressure" is conducted to the cylinders 53, 54 by means of a conduit 101, which interconnects the regulating valve 100 with the main air line 80, a conduit 102 which interconnects the valve 100 to the aforedescribed conduit 91, there being interposed in the latter conduit a pressure-controlled poppet valve 103 which is under the influence of the pilot valve 98, being also connected for its control to the conduit 99, as shown in Fig. 1. Thus the conduit 102 is also divided into two portions, namely, a portion 102*a* which is interposed between the valve 100 and the poppet 103, and the portion 102*b* which interconnects the poppet valve 103 with the conduit 91.

The in-pressure regulating valve 100 is provided with a suitable manually adjustable knob 100*a* by which the in-pressure or back pressure can be controlled which acts against the fluid under pressure coming via the cam controlled valve 59.

Although one of the principal objects of the present invention is to provide novel means for maintaining a minimum uniform contact pressure (rewind roll vs. contact drum pressure) during the build-up of the rewind roll, such pressure sometimes being referred to as "kiss" pressure, such uniform minimum pressure is normally applicable for the rewinding of relatively light, thin and stretchy web material. In the case of slitting and rewinding of substantially heavier and stiffer web material, it may be desirable, in lieu of the minimum uniform pressure, to substitute a relatively heavier pressure which should be, however, maintained at a uniform value throughout the build-up of the rewind rolls. This can be achieved by the adjustment of the "in-pressure" valves **100** and **100***b* (Fig. 1).

The poppet valve **103** is analogous in operation to the poppet valve **97** and blocks off or isolates the in-pressure regulating valve **100** whenever the handle **82** is moved away from its central or run position.

The extent of the aforementioned in-pressure controlled by the regulating valve **100** can be determined by observing a gauge **104** which is in communication with the conduit **91**.

We also have found it desirable to apply a pressure axially of the rewind shafts **21** and **22** against the cores upon which the rewind rolls are wound and such pressure may be applied by suitable fluid pressure means as shown in the lower portion of Fig. 1 wherein it will be observed, for example, in connection with the rewind shaft **21** that a pressure sleeve **105** is employed which is urged to the left by means of a piston rod **106** which is under the influence of air pressure within a cylinder **107** in a well known way. Such pressure is conducted to the sleeve **105** by means of a crank **108** which presses against a rod **109** and thence upon an intervening plate **110**. Air under pressure is conducted to the cylinder **107** by means of a conduit **111** which is in communication with the main fluid supply cylinder **80**. There is a hand-controlled pressure adjusting valve **112** interposed in the conduit **111**, the pressure being adjustable by observing a gauge **113**.

System for balancing web pull torque (brought about by center rewind torque) against belt pull torque (brought about by the drive belt for effecting center rewind torque), both torques acting about the support arm pivot axis

Referring now to Figs. 1, 10 and 11, there will be described a system for balancing:

(*a*) the torque which is exerted upon the rewind shaft support arms (acting about the pivot axis thereof) which is attributable to the pull of the web as it is wound upon the rewind shaft under the influence of the torque applied directly to the rewind shaft (center rewind torque); and

(*b*) the torque acting upon such support arms also about the pivot shaft axis thereof, which torque is attributable to the belt driving means for the rewind shaft.

A general analysis of the objectives of the system for balancing web pull torque and center rewind torque against one another requires the consideration of the following facts:

The contact drum is driven, in the embodiment shown, at a constant speed and each rewind shaft is driven at a gradually diminishing speed, such speed control being accomplished by means shown in the aforementioned patent to T. N. Carter No. 2,650,039. The invention, however, is not necessarily limited to this particular type of speed control but we have found it to be advantageously adapted to this invention. Furthermore, the invention is not limited to the driving of the contact drum at a constant speed with the rewind shaft being driven at a gradually diminishing speed. For example, it would be possible to drive the contact drum at a changing speed but with the rewind shaft being driven at a speed differential (compared to the contact drum) which is analogous to that occurring when the contact drum is driven at such a constant speed or angular velocity.

Thus the present apparatus employs what is known in the art as "center rewind" and "contact rewind," that is the rewind torques are respectively attributable to: a driving torque exerted on the rewind shaft per se, and a torque occurring because of the peripheral contact between the rewind roll and the driven contact drum. In view of the fact that "center rewind" is employed (that is, a direct driving of the rewind shaft), the web inescapably is placed under a tension because of the torque acting upon the rewind shaft. Such tension produces a reaction which (in the case of the front shaft shown) forms a moment known as a web tension moment and which tends to urge the rewind shaft support arms **23**, **24** toward the contact drum thereby to alter the contact pressure, that is, to alter the pressure between the periphery of the rewind roll and the contact drum. It is such alteration of contact pressure which this balance system seeks to avoid. The web tension moment, of course, may urge the support arms in the opposite directions, as in the case of the rear rewind arms. However, in this particular example regarding such front support arms **23**, **24**, the web tension moment tends to increase and thus to increase the contact pressure as rewind diameter (R) increases. However, the invention is not limited to such an increasing web tension moment. Thus, it is a further object of this balance system to minimize the effect of such web tension moment, whatever its direction or manner of changing, or to reduce its effect to negligible proportions by bringing into play a countertorque attributable to the endless band or belt means which drives the rewind shaft.

In those cases where no center rewind torque is exerted on the rewind shaft, there is no need for counterbalancing such web tension moment attributable thereto because the latter will not arise. Thus, such a center rewind torque must exist in order for this particular balance system to be brought into play. However, such a center rewind torque is not necessary for the operation of the two static weight counterbalancing systems herebefore described.

In general, we have found that an advantageous way to counterbalance such web pull is to drive the respective rewind shafts by belt means wherein an endless belt or band passes over a rewind shaft pulley, preferably coaxial with and keyed to the rewind shaft, and also passes over a drive pulley which is located near the respective pivot or axis of the support arms. By offsetting in a special way the axis of the drive pulley with respect to the axis of the pivot shaft, we have found that an adequate compensation for the aforementioned web pull can be attained, such compensation or counterbalancing being effected by a counterbalancing moment which in turn acts against the moment which is attributable to web pull. That is, a counterbalancing torque is automatically exerted upon the support arms about the axis of their pivot shaft, which counterbalancing torque differs only to a negligible degree or not at all with the torque acting upon said arms attributable to the web pull.

An analysis of the procedure whereby the direction and the extent of offset of the aforementioned axis of the drive pulley with respect to the axis of the pivot shaft, will now be set forth.

Referring now to Figs. 1, 10, 11 and 11*a*, the rewind shaft **21** is preferably driven by means of endless band means, such as an endless belt **114** which respectively passes over: a rewind shaft pulley **115** secured to and coaxial with the rewind shaft **21**, and over a drive pulley **116**. The direction and extent of offset of the axis or pivot of the latter pulley results in the counterbalancing of web pull as herein set forth. We have found it advantageous, but not mandatory, for the belt **114** to be of flexible material, for example, of tough steel wire bonded together with or impregnated by a rubber-like material, the belt having formed on the inner surfaces thereof a plurality of parallel transversely extending ridges **114***a* (Fig. 10) which are uniformly spaced and designed for meshing with complementary ridges or teeth upon the peripheries of the pulleys **115** and **116**. A positive drive thereby is attained.

The pivot axis (or primary axis) of the front supporting arms **23**, **24** is indicated by **117**, whereas the pivot axis of the drive pulley **116** is indicated at **118** and is offset therefrom in a direction and by an amount as hereinafter set forth.

In view of the extent and direction of offset of the axis **118** with respect to axis **117**, it will be seen that suitable slack take-up means must be employed for the belt **114**. Such means comprise a slack take-up roll **119** (Fig. 10) mounted upon a lever arm **120** which is mounted for pivotal movement upon a pivot shaft **121** and which lever arm is resiliently urged against the inner run of the belt **114** by suitable means, such as a pneumatic power cylinder **120***a*. Such slack take-up means preferably should engage the belt on the run thereof which is opposite to the run which effects the belt tension reaction for balancing the web pull.

As is well shown in Fig. 10, the web of material to be slit and rewound is first unwound from a parent roll **122**, such web being designated **123**, and passes over the several rolls as shown through a tension control device **124** and thence via a roll **125** onto the contact drum **29** against which the slitting is effected by means of a plurality of slitter wheels, one of which is shown at **126**. Each of such wheels is mounted upon suitable supporting arms, one end of which is angularly shiftable about a fixed pivot and the other end of which is urged toward the contact drum by means of a pneumatic power cylinder **127** which receives air under pressure via a conduit **128**.

The rear rewind shaft **22** is driven in a manner analogous to the front shaft **21**, by means of an endless belt **129** of similar construction and in which the slack is taken up by a slack take-up device **130** which is urged against the outer run of the belt by means of a pneumatic cylinder power device **131**.

The terms and abbreviations herein employed refer, for illustration only, to the front shaft system and are as follows:

B=Belt moment arm about the arm pivot, i. e., the perpendicular distance from the arm pivot axis **117** to a line tangent both to drive pulley **116** and rewind shaft pulley **115** (such tangent following along one run of the belt).

W=Web tangent moment arm acting about the arm pivot **117**, i. e., the perpendicular distance from the arm pivot axis **117** to a line tangent to the rewind roll (contact drum) at the point of contact between such roll and drum. Such tangents are shown at **117***a* and **117***b* (for minimum and maximum values of rewind roll diameter).

T=Belt tension (pull on drive belt), acts in a given direction about the arm pivot, i. e., acts in the direction of the tangent described in connection with B.

P=Web tension reaction (must produce a moment opposed to that of T), acts in the direction of the tangent described in connection with W.

D=Diameter of contact drum **29**.

d'=Diameter of drive pulley **116**.

d=Diameter of rewind shaft pulley (e. g. 4.186")

(*Note*:—*d* and *d'* are equal in the form shown but can be unequal.)

R=Rewind roll diameter.

X=Distance between arm pivot **117** (primary axis about which rewind shaft support arms pivot) and drive pulley axis **118**.

ϕ=Angle, as measured clockwise about the arm pivot axis **117** (Fig. 11), between: (*a*) The center line **23***a* between the arm pivot axis **117** and the rewind shaft axis **21** at some selected rewind roll diameter, e. g., 3½"; and (*b*) The line from the arm pivot axis **117** to the drive pulley axis **118**.

A=Angle between points $1'_1$ and $1'_2$ as measured from the center of the constant drum, that is, the angle between the two points of tangency between the rewind roll and contact drum with R at its minimum and maximum values respectively.

M=The radius of the supporting arm for the rewind shaft.

Now referring to Fig. 11*a*, the following general calculations and equations should be considered:

(1) Belt tension moment or torque on arm (about arm pivot or primary axis) due to belt pull=T(B).

(2) Web tension moment or torque on arm (about primary axis) due to web reaction=P(W).

(3) Desired relation of such torques is

$$T(B)=P(W)$$

as R builds up.

(4) For convenience, the term P(W) (web tension moment) should be obtained in terms of belt tension T, whereby an easy comparison of the two opposing moments can be made in view of the fact that belt tension moment is also in terms of T.

Therefore, consider an equation of the torques or moments about the axis of rewind shaft **21** (Fig. 11*a*):

(*a*) $$\frac{PR}{2}=\frac{Td}{2}$$

(*b*) $$P=\frac{Td}{R}$$

(*c*) Web tension moment

$$PW=\frac{dTW}{R}$$

(*d*) Since it is desired for web tension moment

$$\frac{(dTW)}{R}$$

to counterbalance belt tension moment TB as closely as possible during rewind roll build-up, i. e., during increase in R, that is, whereby:

$$TB=\frac{dTW}{R}$$

(or substantially so) the direction of offset (ϕ) and extent of offset (X) of the axis of the drive pulley is selected to bring about the above equation as closely as possible as R builds up.

That is, when:

TB is substantially balanced by

$$\frac{dTW}{R}$$

or

B is so balanced by

$$\frac{dW}{R}$$

(as R varies between its limits, e. g. 3½" to 20"), then X and ϕ are determined. Thus X and ϕ are selected to bring about the aforementioned balance or substantial balance as R varies.

Bearing in mind the two basic formulae to calculate the pertinent moments due to web tension and belt tension (in terms of belt tension T), namely, web tension moment=

$$\frac{W\times 4.186\times T}{\text{Rewind diameter}}$$

and belt tension moment=$B\times T$, the following table of moments is arrived at, assuming that the rewind pulley diameter is, for example, 4.186" and that the diameters of both the rewind pulley and the drive pulley are identical:

FRONT ARM WEB MOMENT—TORQUE MOMENT ANALYSIS

← Towards Contact Drum → Away from Contact Drum

Rewind Dia., inches	(W) Web Tangent Mom. Arm About Arm Pivot, inches	Web Tension Moment in Terms of Belt Tension "T"	Belt Moment Arm (B), inches	Belt Ten. Mom.
3½	1.08	←1.3T	1.05	→1.05T
5	1.3	←1.09T	1.0	→1.0T
7	1.48	←.885T	.95	→.95T
9	1.82	←.848T	.90	→.90T
12	2.39	←.835T	.84	→.84T
15	2.97	←.83T	.79	→.79T
20	4.08	←.856T	.75	→.75T

From the table of moment arms and moments above set forth, and with particular reference to Fig. 11, it will be seen that the belt moment arm B varies between the respective maximum and minimum values B_1 and B_2, namely, from 1.05″ down to .75″ and also that the web tangent moment arm W varies between the values W_1 (minimum) to W_2 (maximum) and that these values respectively are 1.08 inches and 4.08 inches. Thus the belt moment arm diminishes by approximately 25% whereas the web tangent moment arm increases in the neighborhood of 400%.

We have found that there is an adequate counterbalancing of the web tension moment by the belt tension moment, as shown in Fig. 12, when the values of B and W vary, as shown in the table above set forth.

We have found it desirable to select the diameter D of the contact drum and the location of the arm pivot in such a way that as the rewind roll diameter R increases, the angle A is relatively small, say, of the order of 15° whereby the web moment arm W will vary, for example, from about 1 to 4, as shown in Fig. 11. Thereafter, the drive pulley pivot is positioned to produce a diminishing value of B as R increases, that is, the rewind roll diameter increases. Preferably, the length of arm M (Fig. 11) is about equal to the distance between axis **117** and the axis of drum **29**.

It would be desirable to locate the arm pivot for the front arm (Fig. 11) in such a way that the value of W varies between limits that are substantially the same as those of the rewind roll diameter. For example, in the present example, the rewind roll diameter varies between 3½″ and 20″, which by ratio is from 1 to 5¾ approximately. Practical design considerations which limit the size of the apparatus, however, indicate some difficulty to cause W to vary between 1 and 5¾, as aforementioned, and in fact in the form shown we have found that such variation advantageously is between 1 and about 4. Consequently to compensate for the inability of the value W to increase by the desired ratio (comparable to that of the rewind roll), the location of drive pulley pivot axis is selected in such a way that the value of B diminishes, for example, by approximately 25% with respect to the front arm system. With respect to the rear arm, the decrease is, in that example, somewhat greater, the conditions, however, being somewhat different with respect thereto.

Referring now to the rear arm of Fig. 11, it will be seen that the direction of the web moments (e. g. 119 for $R=20''$) acting upon the rewind shaft supporting arm act in a counterclockwise direction due to the attitude of the rewind roll with respect to the contact drum and also due to the angle at which the web moves off of the contact drum and onto the rewind roll. In view of this, the belt tension reactions (e. g. 120 for $R=20''$) must be in an opposite direction and clockwise, the web reactions being counterclockwise. That is, since the web reactions with respect to the rear arm tend to move the arm away from the contact drum, the belt reactions must tend to move it toward the contact drum.

With respect to the front arm, the web reactions obviously urge the arm towards the contact drum and consequently the belt reactions must urge such arm away from the drum in order to counterbalance same.

In the determination of X and ϕ, without making an exhaustive mathematical study of the determinants therefor, it will be seen that the principal mission is to select X and ϕ in such a way that (as R varies from its minimum to its maximum value) B should equal as closely as possible

$$\frac{dW}{R}$$

A study of this equation indicates that one of the initial determinants is the quotient

$$\frac{d}{R}$$

which should be considered from the following points of view:

(*a*) Its actual mathematical value as R changes from minimum to maximum, and

(*b*) The direction of its variation as R so changes. In the present instance R changes from 3½″ to 20″ and consequently the upper and lower value of the quotient

$$\frac{d}{R}$$

are in this special instance (where $d=4.186''$) 1.095 and .2095. Thus the quotient

$$\frac{d}{R}$$

is a diminishing function, diminishing in the ratio roughly from 5 down to 1. It is found, in this particular case, that

$$B=\frac{d}{R}\cdot W$$

if B varies between 1.08 and .75 as shown in the table above.

Referring to the front arm of Fig. 11, one example of the values of X, ϕ and M are: 1.36″; 313°; 30′; and 14″ respectively.

There is thus provided a novel slitting and rewinding apparatus which achieves superior results in the control of roll density, internal tension and quality of roll edge and which meets the most exacting quality control demands at heretofore unattained production rates, the apparatus being capable of reaching speeds up to 2,000 ft. per minute depending upon the width of the web and its character. The novel apparatus provides in a single machine heretofore unattained versatility in that it is capable of slitting and rewinding the following types of web material: light, heavy, stretchy, rigid, laminates, waxed and coated papers, kraft, foil, impregnated fabrics. Rewind rolls produced on this apparatus provide the precise degree of softness or hardness which may be required for shipping, storage and subsequent end use. The automatic rewind density control herein described is adjustable while running, for example, by adjustment of the in-pressure control valve **100** and/or **100*b***, and also by the adjustment of the indicators **66** and/or **66*a*** (Fig. 1).

Furthermore, suitable means are employed for positively isolating the "rewind tension," that is, the tension of the web as it leaves the contact drum, and the so-called "unwind tension," namely, the tension of the web as it is unwound from the parent roll.

The slitting of the web can be accomplished by any one of the several well known means, one of which is shown in the aforementioned patent to T. N. Carter 2,650,039.

The consistently accurate means for controlling the aforementioned rewind roll vs. the contact drum pressure substantially eliminates operator guesswork during the operation of the apparatus. Also rewind rolls of unvarying quality are assured. Once a satisfactory "run" for any type of material has been achieved, the setting or adjustments of the apparatus permit perfect reproduction of such satisfactory run and the pressure, sensitivity and wide range of control means provides optimum running conditions for a heretofore unattained variety of materials. By eliminating the aforementioned guesswork heretofore incidental to hand set adjustments in prior art apparatus in favor of highly sensitive control means, such as the pneumatic system of Fig. 1, the novel apparatus insures constant dependability on long rewind runs.

The present invention employs a combination surface and center rewind principle, that is, the rewinding of the rewind rolls is effected by driving the rewind shaft (center rewind) and also by driving the contact drum, the latter being rotated at a constant angular velocity (surface rewind). The rewind rolls are rewound in two separate groups, as is well known in the art, one group being on the front rewind shaft and the other group on the rear rewind shaft, the individual rewind rolls being staggered on the separate shafts and well separated, thus effecting a positive roll separation.

By virtue of the neutralization of the torques, heretofore occurring in prior art apparatus, namely: (*a*) those exerted upon the support arms of a given rewind shaft, attributable to the static weight of the roll material as it builds up; (*b*) also those attributable to the static weight of such arms and shaft; and (*c*) the torques incidental to web pull and "center rewind," a precisely controllable contact pressure (rewind vs. contact drum pressure) is attained by the differential between the pressures on opposite sides of the pneumatic power cylinders, e. g. **53** and **54**. By the use of such pressure differential, heretofore unattained accuracy of quality control is attained, particularly with respect to roll density.

Although only a single embodiment of the present invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. For example, regarding the means for counterbalancing the static weight of the support arms and rewind shaft, instead of the counterbalancing springs, such as **30**, **31** or **42**, **43**, other suitable means can be employed in other forms of the invention, such as a counterweight system adjusted to counterbalance the aforementioned static weight as the support arms shift angularly. Also regarding the system for counterbalancing the static weight of the rewind rolls as they build up, in lieu of the particular pneumatic counterbalancing system as shown in Fig. 1 employing the pneumatic cylinders (for example, **53**, **54** acting on the rear support arms), it is possible in other forms of the invention to employ other force exerting devices which can create a torque or moment acting upon the support arms which is counter to the moment due to the action of gravity upon such rolls as their diameter increases. For example, a mechanical counterbalancing of this type may be employed, including a counterweight, which may be shiftable along a scale beam by, for example, electrical means in response to the angular movement of a given pair of support arms or to the extent of movement of the axis of the rewind (or roll) shaft from a norm position as in the embodiment of Fig. 1. That is, the countermoment for counterbalancing the static weight of the rolls can be effected in other embodiments by means which can be actuated in response to movement of the axis of the rewind shaft from some norm and employing, of course, the density of the material as one of the governing factors. In connection with the counterbalancing of torque upon the support arms attributable to web pull (brought about by center rewind torque) in substitution for the endless belt with the drive pulley axis offset from the support arm pivot axis herein shown and described, there may be employed a gear train linkage from a suitable power source, such as a motor, operatively connected to the rewind shaft. In Fig. 11*b*, an example of such a linkage is shown designated by the numeral **132**. Only one of such linkages will be described for one of such support arms, it being understood that a similar gear train may be employed for the other support arm of a given pair. A support arm **133** rotatably supports a rewind shaft **134** at its upper extremity and is pivotally mounted at its lower extremity **135**. The rewind shaft has secured thereto a gear **136** which is operatively connected to a motor **137** through the intermediary of the gear train shown which comprises six toothed consecutively meshing gears **138**—**143**, inclusive, the pivot shafts of which are mounted upon the support arm **133**. The feature of the modification of Fig. 11*b*, which is analogous to the offset pivot feature of Fig. 11, comprises a driving gear **144** (analogous to drive pulley **116**), the axis **145** of which is offset from the pivot arm axis **135** in a manner analogous to the offsetting of the axis of the drive pulley pivot, as shown in Fig. 11. The driving gear **144** is drivably connected to the gear train **138**—**143** through the intermediary of gears **146** and **147** which are mounted upon a lever arm **148**. One extremity of the lever arm **148** is pivotally secured to the arm **133** at **143*a*** lever arm **148** is pivotally secured to the arm **133** at **143*a***, comprising the axis of the gear **143**, and at the opposite extremity of the arm **148** the gear **147** is rotatably mounted about an axis **147*a*** comprising the pivot axis of the gear **147**. A supplementary arm **149** is pivotally mounted at one extremity at **147*a*** and at the opposite extremity at the pivot **145** and is able angularly to shift about the latter pivot which is fixed. The pivot **135** also is fixed. As torque is applied to the drive gear **144**, it will exert a torque upon the support arms **133** via the arm **148** which is analogous to the torque exerted upon the support arm, for example **24** (Fig. 1), by the belt **114**.

In a separate and non-equivalent embodiment of the invention, in lieu of mounting the rewind shaft upon support arms, such as **23**, **24**, such arms may be dispensed with and the opposite extremities of the rewind shaft, e. g. **21**, can be supported in suitable tracks formed, for example, in either straight or curved parallel slotted or grooved members, suitable means being provided, of course, to prevent the rewind shaft from becoming askew or canted with respect to such slotted members. Such members are provided with said tracks for receiving the opposite extremities of such a rewind shaft and for guiding same, for example, in substantially the same curved path as shown in Fig. 11 although such curved path may be straight.

What is claimed is:

1. In a winding machine, the combination of: a pair of rewind arms, a rewind shaft, means for pivotally supporting said arms at their inner ends for angular movement about a primary axis, said arms being adapted to support said rewind shaft at their outer ends on which shaft a web of sheet material is to be rewound into a rewind roll, a driven contact drum with which such roll is in engagement during the rewinding thereof, a driven pulley mounted for rotation near the outer end of one of said arms and drivably connected to said rewind shaft, a drive pulley mounted near the opposite extremity of said arm for rotation about a secondary axis, and an endless belt interconnecting said pulleys for communicating torque to said rewind shaft to wind such web thereon, means for mounting said drive pulley with its axis of rotation comprising such secondary axis spaced from said primary axis by a selected distance in a selected direction for achieving a balance between the moments acting upon such arms attributable to the tension of such belt and the moments acting upon said arms attributable to the reaction of such web as it is wound upon such shaft while the diameter of such rewind roll increases.

2. In a winding machine, the combination of: rewind arm means, a rewind shaft, means for pivotally supporting said arms at one end thereof for angular movement about a primary axis, said arms being adapted to support said rewind shaft at the other end thereof for angular movement therewith about such axis, and on which shaft web material is to be wound into one or more rewind rolls, a contact drum mounted for rotation in the path of such angular movement of such rewind shaft, such movement occurring about such primary axis, a drive pulley mounted for rotation about a secondary axis near to but spaced from such primary axis, a driven pulley mounted near such other end of said rewind arm means and operatively connected to said shaft for driving same, endless belt means interconnecting said two pulleys, such web being fed to said rewind shaft for being wound thereupon, and passing partly around said drum thereby to create web tension moments acting on said arm means in one direction about said primary axis in response to driving such rewind shaft, said endless belt means creating belt tension moments acting on said arm means about such axis in response to driving said drive pulley, means for mounting said drive pulley with the axis of rotation thereof comprising said secondary axis parallel to but spaced from said primary axis by a selected distance and in a selected direction for creating such web tension moments in an opposite direction about said primary axis substantially to balance said belt tension moments while said rewind roll increases in diameter.

3. Apparatus in accordance with claim 2 wherein said belt tension moment=BT and said web tension moment

$$=\frac{WdT}{R}$$

and further where

$$B=\frac{WdT}{R}$$

substantially, where: B is the perpendicular distance from the arm pivot to a line tangent both to the drive pulley and to the rewind shaft pulley as the rewind roll builds up; W is the perpendicular distance from such arm pivot to a line tangent to the rewind roll at the point of contact between the latter and the contact drum; and T is the belt tension or the tension on the drive belt; d is the diameter of the drive pulley; and R is rewind diameter.

4. In a winding machine, rewind arm means pivotally supported at one end thereof for angular movement about a primary axis, and adapted to support a rewind shaft at the other end thereof, on which shaft web material is to be wound into one or more rewind rolls, a contact drum mounted for rotation about a stationary axis and positioned in the path of movement of the axis of rotation of said first-mentioned shaft, such angular movement occurring about the aforementioned primary axis, whereby web material passing at least partly around said contact drum is wound upon such rewind shaft, power means operatively connected to such rewind shaft for winding such web of sheet material thereupon, thereby to create the aforementioned rewind rolls, the winding of such rolls upon such rewind shaft creating web tension moments about the aforementioned primary axis, means for operatively interconnecting said rewind shaft with a power source for driving same, means for mounting such operative interconnection with respect to the aforementioned primary axis for creating a substantially equal and opposite moment about the primary axis substantially balancing the web tension moment as the rewind roll increases in diameter.

5. In a winding machine, rewind arm means pivotally supported at one end thereof for angular movement about a primary axis, and adapted to support a rewind shaft at the other end thereof, which shaft is adapted in turn for the winding thereupon of web material in one or more rewind rolls; a contact drum mounted for rotation about a stationary axis parallel to the aforementioned primary axis and to the axis of rotation of said rewind shaft; spring means operatively connected with said arm means for counterbalancing the static weight of said arm means including that of said rewind shaft; means responsive to angular movement of said arm means from a norm position for exerting a torque on said arm means as a function of such angular movement thereby to counterbalance the static weight of the web material wound upon said rewind shaft, said arm means angularly moving in response to the build up of web material upon said rewind shaft; driving means for said rewind shaft comprising an endless band passing over a rewind shaft pulley connected to said rewind shaft and positioned near the outer end of said arm means, said band also passing over a drive pulley, the axis of rotation of the latter pulley being positioned near to but offset from said primary axis by a selected distance in a selected direction therefrom responsive to the variation of B as compared to the variation of

$$\frac{dW}{R}$$

where: B is the belt moment arm about the aforementioned primary axis, that is, the perpendicular distance from such axis to a line tangent both to the drive pulley and the rewind shaft pulley; d is the diameter of the rewind shaft pulley; W is the web tangent moment arm about such primary axis, that is, the perpendicular distance from the primary axis to a line tangent to the rewind roll and contact drum at the point of contact between such roll and drum; and R is the rewind roll diameter; and such distance and direction being selected whereby the differences between B and

$$\frac{dW}{R}$$

as R is increased, are of negligible amount.

6. In a winding machine, rewind arm means pivotally supported at one end thereof for angular movement about a primary axis, and adapted to support a rewind shaft at the other end thereof, which shaft is adapted in turn for the winding thereupon of web material in one or more rewind rolls; a contact drum mounted for rotation about an axis parallel to the aforementioned primary axis and to the axis of rotation of said rewind shaft; driving means for said rewind shaft comprising an endless band passing over a rewind shaft pulley connected to said rewind shaft and positioned near the outer end of said arm means, said band also passing over a drive pulley, the axis of rotation of the latter pulley being positioned near to but offset from said primary axis by a selected distance in a selected direction therefrom responsive to the variation of B as compared to the variation of

$$\frac{dW}{R}$$

where: B is the belt moment arm about the aforementioned primary axis, that is, the perpendicular distance from such axis to a line tangent both to the drive pulley and the rewind shaft pulley; d is the diameter of the rewind shaft pulley; W is the web tangent moment arm about such primary axis, that is, the perpendicular distance from the primary axis to a line tangent to the rewind roll and contact drum at the point of contact between such roll and drum; and R is the rewind roll diameter; and such distance and direction being selected whereby the differences between B and

$$\frac{dW}{R}$$

as R is increased, are of negligible amount.

7. In a winding machine, rewind arm means pivotally supported at one end thereof for angular movement about a primary axis; a rewind shaft supported at the other end of such arm means for rotation about an axis which is parallel to said primary axis, said rewind shaft being adapted for the winding of web material therearound in one or more rewind rolls; a contact drum mounted for rotation about an axis parallel to the aforementioned primary axis and to the axis of rotation of said rewind shaft, said rewind rolls and drum being in peripheral contact when the machine is in operation; and means for selectively controlling the pressure of such contact independent of the static weight of such arm means, shaft, rolls, and of a web reaction torque set forth below, such means including: means operatively connected with said arm means for counterbalancing the static weight thereof including the static weight of said rewind shaft, means responsive to the extent of angular movement of said arm means about said primary axis for exerting a torque upon said arm means acting about said primary axis, such torque being a function of the extent of such angular movement thereby to counterbalance the static weight of such web material wound upon said rewind shaft as such weight increases, means for driving said rewind shaft thereby to rewind said web material thereon, the driving of said shaft producing a web reaction torque acting on said arm means, means for mounting said driving means for producing a torque which substantially counterbalances said web reaction torque, and adjustable means for exerting force for urging relative movement of said drum and shaft.

8. In a winding machine, arm means pivotally supported at one end thereof for angular movement about a primary axis, a driven shaft supported at the other end of such arm means for rotation about an axis which is parallel to said primary axis, said shaft being adapted for the winding of web material therearound in one or more rolls; the driving of said shaft producing a web reaction torque acting on said arm means, and means for balancing said web reaction torque.

9. In a winding machine, a rewind arm device pivotally supported at one end thereof for angular movement about a primary axis; a rewind shaft mounted for rotation at the other end of such rewind arm device, such rewind shaft being driven and being positioned for rotation about an axis parallel to such primary axis and being adapted for the winding of web material thereon in one or more rewind rolls; a contact drum mounted for rotation about an axis parallel to the aforementioned axes, said rewind rolls and drum being in peripheral contact when the machine is in operation; and means for making the pressure of such contact independent of the static weight of such rewind arm device, rewind shaft, rewind rolls and of a web reaction torque set forth below, such means including: means operatively connected with said arm device for counterbalancing the static weight thereof including the static weight of the rewind shaft mounted thereupon, power means for exerting torque upon said arm device, and means for controlling said power means in response to the angular displacement of said arm device from a selected norm position, such angular displacement being in turn responsive to change in diameter of such rolls whereby the static weight of web material wound upon said rewind shaft is counterbalanced, the aforementioned web material passing at least partially around said contact drum and thence being wound upon said rewind shaft and exerting a torque upon said arm device about said primary axis attributable to web tension reaction resulting from such shaft being driven as aforesaid; driving means for driving same as aforementioned and thus for said rewind shaft for applying a driving torque thereto, and means for mounting said driving means for producing a torque for substantially counterbalancing said web reaction torque.

10. In a winding machine, a rewind arm device pivotally supported at one end thereof for angular movement about a primary axis, a rewind shaft mounted for rotation in the other end of said rewind arm device about an axis which is parallel to said primary axis, said rewind shaft having a torque directly applied thereto for the winding of web material thereupon in one or more rewind rolls cut from a parent roll; a contact drum mounted for rotation about an axis parallel to the aforementioned axes, said rewind rolls and drum being in peripheral contact when the machine is in operation; primary counterbalancing means operatively connected with said arm device for counterbalancing the static weight thereof including the weight of the rewind shaft mounted thereupon; said primary counterbalancing means comprising spring means operatively connected with said arm device for deformation in response to angular movement of said arm device from a selected norm position whereby the aforementioned counterbalancing of such static weight is effected; secondary counterbalancing means for counterbalancing the static weight of the web material as it is wound up upon said rewind shaft and comprising means for exerting a torque upon said arm device in response to the angular movement of said arm device from a selected norm position as the diameter of the rewind roll thereupon builds up; said web material being wound upon said primary shaft creating a web tension moment about the aforementioned primary axis responsive to the driving of said rewind shaft which moment varies as such rewind roll diameter builds up; and tertiary counterbalancing means for substantially fully counterbalancing the aforementioned web tension moment as the latter varies in response to the build-up of rewind roll diameter.

11. In a winding machine, the combination including: a pair of rewind arms pivotally supported at one end thereof for angular movement about a primary axis, a rewind shaft mounted upon the other ends of said rewind arms and positioned there for rotation about an axis which is parallel to said primary axis, said rewind shaft being adapted for the winding thereupon of web material in one or more rewind rolls; a contact drum mounted for rotation about an axis parallel to the aforementioned axes, said web material passing at least partially around said contact drum and onto said rewind rolls upon said rewind shaft, said rewind rolls and drum being in peripheral contact; the static weight of said rewind shaft and rewind arms exerting a moment about the aforementioned primary axis, primary counterbalancing means for exerting a primary torque upon said rewind arms thereby to counterbalance the aforementioned static weight, such primary torque being a function of the extent of angular movement of said rewind arms from a selected primary norm position; a further torque being exerted upon said rewind arms about the aforementioned primary axis as a result of the static weight of the web material wound thereupon in said rewind roll or rolls, said torque varying in response to the build up of the diameter of said roll, secondary counterbalancing means for exerting a secondary counterbalancing torque upon said rewind arms for counterbalancing the aforementioned further torque due to rewind roll static weight, said secondary torque exerting means being responsive to the angular movement of said rewind arms from a secondary norm position as rewind roll diameter increases; the aforementioned web material passing at least partially about said contact drum exerting a web tension moment upon said rewind arms responsive to the driving of such rewind shaft, such moment acting about the aforementioned primary axis, and tertiary counterbalancing means for exerting a tertiary counterbalancing torque upon said rewind arms thereby to counterbalance the aforementioned web tension moment as the latter varies in response to the building up of rewind roll diameter.

12. In a winding machine, the combination of: a contact drum, a roll shaft on which sheet material is to

be wound in one or more rolls, drive means connected to said roll shaft for rotating same thereby to wind such sheet material thereupon, the axes of said roll shaft and contact drum being so disposed with the web of sheet material being wound upon the roll shaft under tension and exerting a force upon such roll shaft tending to cause relative movement of the axis of such shaft with respect to that of the contact drum, and means for counterbalancing such force.

13. In a winding machine, a driven roll shaft adapted for the winding thereon of web material in the form of a roll, a contact drum, the force of gravity acting upon said roll shaft due to the mass thereof, such force of gravity also acting upon the sheet material wound thereupon in the form of such roll, a further force acting upon said rewind shaft attributable to the tension of the sheet material as it is wound upon the roll shaft by virtue of the fact that such shaft is driven as aforementioned, such forces tending to cause relative movement of the axis of such roll shaft and the axis of such contact drum, such contact drum and material rolled upon the roll shaft being peripherally in engagement during the winding of the web material thereon, and means for respectively neutralizing such forces during the driving of such roll shaft and thus as the distance changes between the axis of said contact drum and the axis of said roll shaft.

14. In a winding machine, a roll shaft adapted for the winding thereon of web material in the form of a roll, a contact drum, power means connected to said shaft for exerting a driving torque thereon for driving same and thereby winding such material thereon, the force of gravity acting upon said roll shaft due to the mass thereof, such force of gravity also acting upon the sheet material wound thereupon in the form of such roll, a further force acting upon said rewind shaft attributable to the tension of the sheet material as it is wound upon such roll shaft by virtue of the fact that such shaft is driven as aforementioned, such forces tending to move the axis of such roll shaft with respect to the axis of such contact drum, means for respectively neutralizing such forces during the driving of such roll shaft and thus as the distance changes between the axis of said contact drum and the axis of said roll shaft, such contact drum and material rolled upon the roll shaft being peripherally in engagement, and means for exerting a controlled force for urging said axes toward one another.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,872,126 February 3, 1959

Leonard Rockstrom et al

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 68, for "cusioning" read -- cushioning --; column 8, line 14, for "plating" read -- placing --; column 11, line 70, for "constant" read -- contact --; column 19, line 70, claim 9, beginning with "driving means" strike out all to and including "torque thereto", in line 72, same column, and insert instead -- driving means for said rewind shaft for driving same as aforementioned and thus for applying a driving torque thereto --.

Signed and sealed this 8th day of September 1959.

(SEAL)

Attest:

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