United States Patent

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[54] WEB WINDING APPARATUS
11 Claims, 4 Drawing Figs.

[52] U.S. Cl. 242/56.2, 242/56.9, 242/67.5, 242/75.51
[51] Int. Cl. B65h 35/02
[50] Field of Search 242/56.1, 56.2, 56.4, 56.9, 67.1, 67.5, 75.5, 75.51; 318/6

[56] References Cited

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ABSTRACT: A web-winding system is disclosed as employing clutches so ganged on a common drive that wide webs may be wound simultaneously with, and to the same tightness as, narrower webs. The coupling of each such clutch is controlled by a computer which operates by maintaining constant the total end face area of the supply and rewind rolls. The drive speed is also computer-controlled to minimize the heat-producing slippage within such clutches.

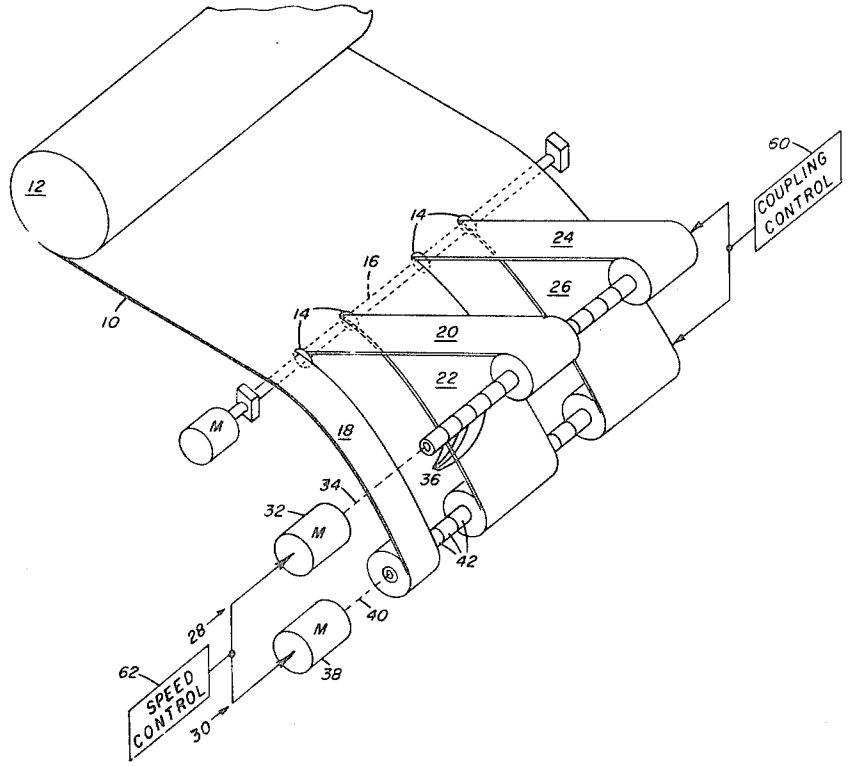


FIG. 1

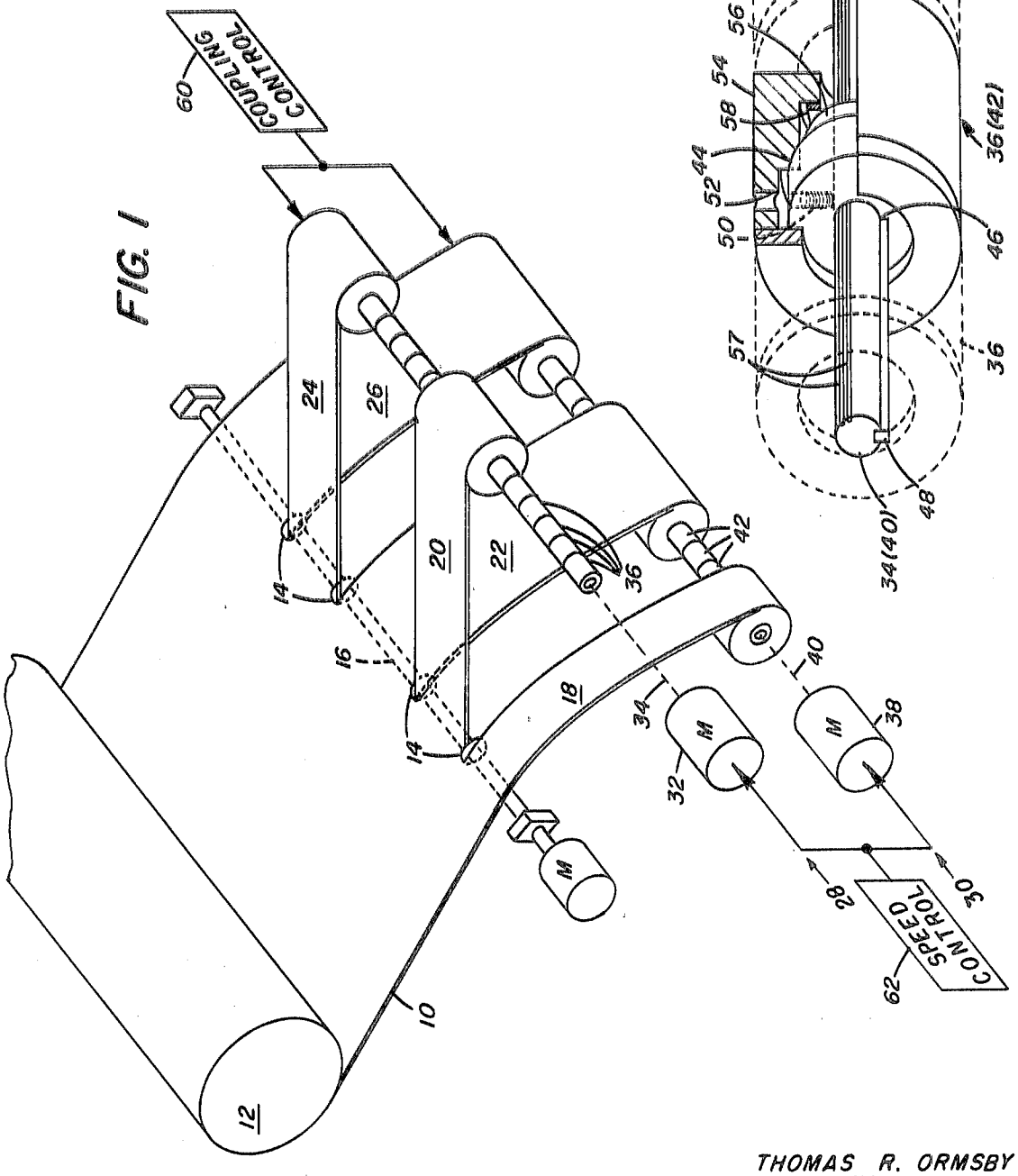
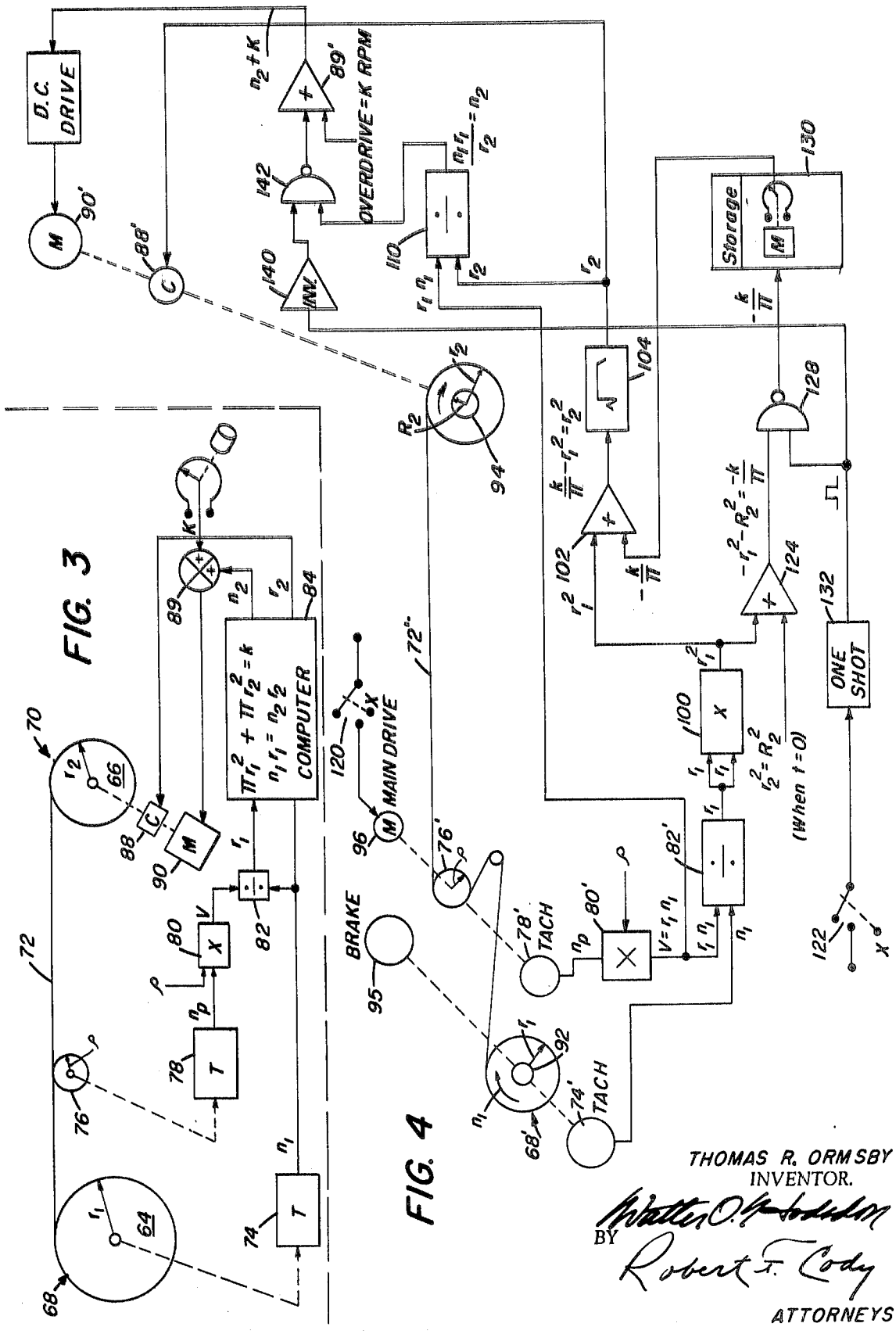


FIG. 2

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WEB WINDING APPARATUS

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This invention relates in general to web-handling equipment. While one aspect of the invention is directed to the simultaneous winding of plural webs to the same roll tightness, other aspects of the invention may find usefulness in controlling the winding of any number of webs.

2. Description Relative To The Prior Art

In the field of web winding, it is well known to increase the torque of winding apparatus as the radius of the web roll in question increases, thereby to control the tightness of such roll. U.S. PAT. No. 2,684,210 particularly points out how this technique may be implemented by use of a slip clutch, the coupling of which is adjusted in relation to roll radius. U.S. PAT. No. 2,684,210 further suggests that the drive input speed of the clutch may be reduced as the radial dimension of the roll increases, thereby to decrease slippage within the clutch, and thus prolong clutch-life. U.S. PAT. No. 2,796,222 similarly indicates, in web-handling apparatus, the control of clutch coupling and input speed; and particularly indicates how the problem of disposing of heat generated by overdriving the input of the clutch may be avoided by directly measuring clutch slippage, and employing a signal representing such slippage for purposes of clutch input speed control.

Where plural webs of different widths are to be wound simultaneously by the same drive, a problem presents itself if all such webs are to be wound to the same tightness: Winding two rolls of the same instantaneous radius, but of different axial dimensions, requires more torque for the wider roll than for the narrower one. If winding is governed by the torque requirements of the narrower roll, the wider roll will be too loosely wound; if winding is governed by the torque requirements of the wider roll, the narrower roll may cinch under its own tightness. Such manifestations are especially bothersome when winding photographic webs, viz because they tend to degrade optically the surfaces of such webs and/or their coatings.

In determining torque requirements as a function of the radial dimension of a web roll, it is frequently desirable to do so without actually detecting/measuring, e.g. by means of a feeler in contact with the roll, the radius of such roll. And, as will appear below, meeting the torque requirements of apparatus adapted to wind plural webs of different widths augments the need for controlling clutch input speed, especially where thermally nonconductive photographic webs are to be wound. As in the case of torque control without use of roll-feelers, etc., it is often desirable also to control the input speed of a clutch without resort to feedback devices on, or associated with, the roll being wound.

SUMMARY OF THE INVENTION

The invention is indicated in the environment of a system for slitting a wide web, say of photographic film, which has been peeled from a supply roll thereof, into any number of narrower webs (hereinafter sometimes referred to as rewind-webs) of the same or different widths; and then simultaneously winding all such narrower webs into respective rolls thereof. Such a system illustrates the various problems solved by, and features of, the invention:

To meet the torque requirements of web rolls as functions both of their radii and widths, the invention proposes 1, the use of plural clutches on a common drive shaft ——which clutches are so ganged that wider rewind-web rolls are driven by more clutches than narrower rewind-web rolls ——; and 2 the respective coupling of each such clutch in accordance with roll radius. To facilitate such ganging of clutches, the clutches are preferably alike; their respective output members being so dimensionally larger radially (concentrically) than their input members that web winding necessarily occurs on

and about one or more of such output members. Thus, web slitting may occur anywhere, and any number of times, across the width of a wide web, the clutches cooperating in groups to provide wind up torque commensurate with the widths of the respective webs being rewound.

Winding thermally nonconductive (photographic) webs on and about clutches, in the manner indicated above, requires that heat-producing slippage within such clutches be kept to a minimum. Apparatus according to the present invention not only controls the input speed of a clutch—thereby to minimize its slippage—without sensing rewind-web parameters, but also controls the torque of such clutch as a function of the radius of its respective rewind roll, without actually detecting/ measuring the radial dimension of such roll. Such speed and torque controls are made possible by a computer which operates on the following premise: The total end face area of web supply and rewind rolls will be constant provided the tightness of the supply roll is the same as the tightness of the rewind roll; and such tightnesses will be the same provided the web tension between the rolls is kept constant. Based on such premise, the computer provides a signal representing the instantaneous radius of the rewind roll; and by which signal tension-influencing clutch coupling is controlled. Since web-speed is the same for both the supply and rewind rolls, the rotational speed of the rewind roll can be determined from the instantaneous radii of the supply and rewind rolls, and the angular speed of the supply roll. The rewind roll speed is the output speed of the clutch in question; and the input speed to such clutch may be so selected that the clutch slip-speed can be thermally tolerated.

As will be indicated below, and as presently preferred, the total end face area constant is determined without actually measuring such area.

An object of the invention is to provide a way simultaneously to wind into rolls, and by the same drive, webs of different widths; and which rolls will be wound to substantially the same tightness as each other, and throughout.

Another object of the invention is to provide, in a system for rewinding a web peeled from a supply roll thereof, apparatus for regulating rewind torque in accordance with a dimension of the rewind roll, and which dimension is determined from data derived from the supply roll.

Another object of the invention is to provide an input-speed control for a clutch employed for rewinding a web peeled from a supply roll, the coupling of which clutch is adjusted in accordance with a dimension of the rewind roll, and which speed control obviates the need for feedback devices on or associated with the rewind roll.

Another object of the invention is to provide speed and/or torque controls for a clutch employed for rewinding a web peeled from a supply roll thereof, which controls are based on the total area of the end faces of the supply and rewind rolls being maintained constant.

Another object of the invention is to provide a way for determining the total end face area of supply and rewind rolls without actually measuring such area.

Another object of the invention is to provide rewind apparatus embodying any or all of the above-indicated features.

The invention will be described with reference to the figures wherein

FIG. 1 is a perspective view of a system especially adapted to incorporate the various features of the invention,

FIG. 2 is a side elevational view, partially in section, of a clutch useful for practicing the invention,

FIG. 3 is a block diagram indicating a web winding system according to the invention, and

FIG. 4 illustrates, in block form, a presently preferred web winding system according to the invention, and embodying its various features.

Referring to FIG. 1, a web 10 is peeled from a supply roll 12 thereof, and conveyed past slitters 14. While there is no special form of slitter 14 necessary to practice the invention, it is a feature of the invention to accommodate web slitting

anywhere, and any number of times, across the width of the web **10**. For this purpose, the slitters **14** are cutting wheels positionably mounted on and driven by a shaft **16**. Alternate narrow webs **18, 20, 22, 24, 26**, which may be of any selected width, and which are formed by the slitting operation, are wound by respective drives **28, 30**. The drive **28** comprises a motor **32** for driving a shaft **34** to which a plurality of clutches **36** are ganged; the drive **30** comprises a motor **38** for driving a shaft **40** to which a plurality of clutches **42** are ganged.

A clutch of the type indicated in FIG. **2** has been found especially useful for practicing the invention: The input member **44** of the clutch **36** is provided with a keyway **46**; and which keyway **46** cooperates with a key **48** on the drive shaft **34** to lock the shaft **34** and clutch input member **44** rotationally together. A setscrew **50**, accessible through a hole **52** in the clutch output member **54**, keeps the clutch from sliding lengthwise of the shaft **34**. An electromagnet **56**, forming part of the clutch input member **44**, receives electrical coupling control signals (via busses **57** disposed on and along the shaft **34**) for coupling the clutch input and output members together. The output member **54** of the clutch may be of magnetic material; and such output member has a friction ring **58** for bearing the brunt of the clutch coupling forces. The electrical coupling control signals are provided by a control device **60** which increases the electrical power applied to the electromagnet **56** as the torque requirements of the clutch increase, i.e., as the rewind roll(s) grows in radius; and a speed control device **62** operates to decrease gradually the speed of the drive shaft **34** as the rewind roll(s) grows in radius, thereby to cut slippage within the clutch(es) **36** and prevent its (their) overheating.

By the above-described apparatus, a web may be slit anywhere, and any number of times, across its width, the rewind apparatus always providing the requisite torque (regardless of web width or roll radius) for producing rewind rolls all of the same tightness: A narrow rewind web e.g. web **18**) which is half as wide as another (e.g. web **20**) is wound on, and by, half as many clutches as the wider rewind web; but since the rewind rolls in questions similarly grow in radius, their respective clutch couplings are similarly simultaneously increased.

FIG. **3** indicates the general scheme of a computer for providing speed and coupling controls without feelers, feedback devices, etc. Components for preforming the various computer functions are well known; and such components may take any of a variety of forms, as indicated, for example, in "Electric Analog Computers", Korn and Korn, McGraw Hill Publishing Company, Inc., 1952.

It should be borne in mind that in the description which follows, the various parameters, and signals corresponding therewith, are respectively similarly designated.

As indicated above, the total area of the end faces **64, 66** of supply and rewind rolls **68, 70** will be constant k provided the respective tightnesses of such rolls are the same; and such tightnesses will be substantially the same if the tension in the web **72** between such rolls is kept constant. Web tension may be so maintained by controlling the roll **66** torque as a direct function of the instantaneous radius r_2 of the roll face **66**; and such radius may be determined from the instantaneous radius r_1 of the roll face **64** provided the area constant k is known: The area constant is the area of the end face **64** at the start of the winding operation (plus the core area of the rewind roll **70**).

The instantaneous radius r_1 of the supply roll **68** is determined as follows: A tachometer **74** is driven by the supply roll **68**, and provides a signal n_1 representing the rate of rotation of the roll **68**. A roller **76** having a radius ρ is driven by the web **72**; and such roller **76** rotates at a rate dependent upon the lineal speed of the web **72**. The roller **76** drives the input of a tachometer **78**, thereby to produce a signal n_ρ *representing the rotational rate of the roller 76. A signal multiplier (e.g. a potentiometer excited by a voltage representing the roll radius* ρ *and having its wiper positioned in proportion to the signal* n_ρ) produces the product signal V. The signals V and n_1—representing respectively the lineal speed of the web **72** as it peels from the roll **68**, and the angular speed of the roll **68**—are divided by and in a divider **82** to produce the quotient signal r_1 representing the instantaneous radius of the roll **68**.

Based on the above-mentioned premise, a signal r_2 representing the instantaneous roll (**70**) radius which is necessary to keep web (**72**) tension constant is generated by a computer **84** adapted to solve the equation $\pi r_1^2+\pi r_2^2=k$ for r_2; which signal r_2 is applied to vary the torque producing coupling of a clutch **88** to hold web tension constant. Thus, the rewind torque is controlled in proportion to the radius of the rewind roll—without ever actually measuring/detecting such radius.

As the rewind roll **70** rotates to draw web **72** from the supply roll **68**, the rotational rates of the two rolls are tied to each other by the expression $n_1r_1=n_2r_2$; and since signals n_1, r_1 and r_2 are available within the computer **84**, the requisite speed n_2 for the roll **70** may be determined. The roll **70** speed signal n_2 is combined, in a summing device **89** with an overdrive bias signal K, the resultant of which is applied (through an appropriate power control) to a motor **90** for driving the input member of the clutch **88**. Thus, the slip speed of the clutch **88** (i.e. the difference between its input and output speeds) is held to a constant represented by the signal K; and the signal K is so chosen (e.g. depending on the thermal characteristics of the web being wound on and about the clutch **88**) that heat generated within the clutch **88** can be effectively dissipated.

The signal K is necessary to convert the system of FIG. **3** from a static system into a dynamic one.

Reference should now be had to FIG. **4** which indicates a presently preferred form of computer for practicing the invention; and FIG. **4** also illustrates how a good approximation of the total end face area for supply and rewind rolls may be determined without actually measuring such area. Elements having corresponding parts in FIG. **3** are respectively similarly designated in FIG. **4**; but are primed in FIG. **4**.

The supply and rewind roll **68'** and **70'** are provided with cores **92, 94**. The roller **76'** is disposed to assist in stripping web **72'** from the roll **68'**; and the roller **76'** is driven by a motor **96** against the action of a brake **95**. After providing a signal r_1 representing the instantaneous radius of the supply roll **68'**—in the manner of the system of FIG. **3** —the signal r_1 is multiplied by itself in a multiplier **100** to produce the signal r_1^2. The signal r_1^2 is algebraically summed, in a device **102**, with a signal representing the total area constant k divided by π to produce a signal r_2^2; and thereafter a square root device **104** converts the signal r_2^2 to a signal r_2 representing the instantaneous radius of the rewind roll **70'**. (The manner in which the total area constant—divided by π—is produced will be discussed later.) The signal r_2 is then applied to control the torque producing coupling of the clutch **88'**, thereby the keep constant the tension of the web **72'**.

The signal $V(=r_1n_1)$ produced by the multiplier **80'** is applied to a divider **110**, wherein such signal is divided by the signal r_2, to produce the signal n_2 representing that speed for the rewind motor **90'** which is necessary if heat-producing clutch slippage is to be kept to an amount represented by the overdrive signal K.

The total end face area constant k is determined without actually measuring same as follows: At the start of the rewind operation—i.e. when power is first applied to the system of FIG. **4**, by closing ganged switches **120, 122**—the roller **76'** starts to peel web **72'** from the roll **68'**. Thus the signal r_1 is immediately available; and since the core **94** radius is a constant R_2, an algebraic summation device **124** immediately produces the signal k/π. The output signal of the device **124** is, however, only transiently a true representation of the total end face area (divided by π). This is because the supply roll radius r_1 gradually changes as the supply roll decreases in size; and as the size of the rewind roll increases. Accordingly, an AND gate **128** is employed to gate the initial area signal k/πinto a

storage device 130 (e.g. a motor 127—potentiometer 129 combination); and such gate circuit 128 is turned on by means of a one-shot circuit 132 which holds the gate 128 open for just enough time (after the switch 122 is closed) to permit a meaningfully representative area signal to be produced and stored.

During the time when the area signal $k/\pi$is being memorized, the speed control portion of the FIG. 4 system is disabled, thereby to prevent its hunting a continuously changing reference speed. This is effected by inhibiting (inverter 140, AND gate 142) the application of the roll 70' speed signal n_2 to the drive 90'. Rewind speed is a function of the overdrive signal K during this interval.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. For example, it would be within the scope of the invention to attenuate, gradually and slightly, the computed signal r_2 so that outer roll layers are slightly less tightly wound then inner layers.

I claim:

1. Apparatus for winding a web of any given width to a prescribed roll tightness; or for simultaneously winding a plurality of webs having respective widths, and which apparatus winds said plural webs all to the same prescribed roll tightness, comprising:

a. shaft means and a drive therefor,

b. a plurality of slip clutches each of which has input and output members and means for varying the coupling there between, said clutches being so mounted on said shaft means that the respective input members of said clutches are all rotationally driven by said shaft means, the output member of each said clutch being dimensionally larger radially than its corresponding input member, the radial dimensions of said output members being alike, and said clutches being further so disposed on said shaft that respective tandem combinations thereof may wind about their respective output members webs of respective widths,

c. signal responsive means cooperative with the variable coupling means of said clutches for simultaneously adjusting the respective couplings of said clutches, and

d. means for producing and applying a signal proportional to the radius of a roll being wound by said apparatus to said signal responsive means, thereby to control the said couplings in accordance with said signal.

2. The apparatus of claim 1 including means for decreasing the speed of said drive in proportion to the radius of a roll being wound.

3. In a web handling system for slitting a supply web roll into a plurality of narrower rewind webs of respective widths, and for rewinding said narrower webs into rolls thereof, said rolls having respective end face areas, and which system has:

a. a rewind shaft, and

b. means for driving said shaft the improvement which comprises a plurality of similarly sized slip clutches having respective input and output members, and variable coupling means therebetween, said clutches being mounted on said rewind shaft, means for coupling the respective input members of said clutches to said rewind shaft for simultaneous rotation of said input members by said shaft, the output members of said clutches being dimensionally alike and larger radially than their corresponding input members, whereby wider rewind webs are wound on more clutches than narrower rewind webs.

4. The system of claim 3 including means cooperative with said variable coupling means for increasing the coupling of said clutches in proportion to the radii of the rewind rolls being wound.

5. The system of claim 4 including means cooperative with said means for driving said shaft for decreasing the speed of said shaft in proportion to the radii of the rewind rolls being wound.

6. The system of claim 4 wherein said means for increasing clutch coupling comprises computer means cooperative with the end face areas of the supply roll and a rewind roll for producing a control signal representative of the difference between a constant area and the total end face area of said supply roll and said rewind roll, and means for applying said control signal to said variable coupling means.

7. The system of claim 6 including means for continuously producing a signal representing the instantaneous radius of said supply roll, and wherein said computer means is adapted to produce a signal representing the instantaneous radius of a rewind roll which is necessary to maintain constant the said end face area, said last named signal being applied to control the coupling said clutches.

8. The system of claim 7 including:

a. means for producing and applying a signal representing the angular rate of rotation of said supply roll to said computer means, said computer means being further adapted to produce a signal representing the angular speed of said rewind shaft which is necessary to maintain constant the lineal travel of said web from its supply roll to its rewind roll,

b. means for producing a signal representing an overdrive constant, and

c. means for algebraically combining said rewind speed signal and said constant signal into a resultant signal, and for applying said resultant signal to said means for driving said shaft.

9. The system of claim 7 including

a. means independent of said drive shaft for stripping web from said supply roll thereof, and

b. means for producing and storing a reference signal

1. means for producing a signal representing the lineal speed of said web as it is stripped from said supply roll,

2. means for producing at that time a signal representing the angular rate of rotation of said supply roll,

3. means for defining a predetermined short duration at or near the start of said web stripping, which duration occurs before said rewind roll grows appreciably,

4. means for producing a signal representing the quotient of said lineal speed divided by said angular speed, and

5. means cooperative with said last-named means during said predetermined duration for storing thereafter a signal proportional to the square of said quotient signal.

10 In a system for peeling a web off a supply roll thereof and rewinding same into another roll, said rolls having respective end face areas, and which system comprises:

a. slip clutch means having input and output members and means for varying the coupling of said input and output members,

b. means for driving the input member of said clutch, the output member of said clutch being coupled to drive said rewind roll, the improvement comprising computer means cooperative with the end face areas of the supply roll and a rewind roll for producing a control signal representative of the difference between a constant area and the total end face area of said supply and rewind rolls, and means for applying said control signal to said means for varying the coupling said clutch means.

11. The system of claim 10 wherein said computer means includes means for producing a signal representing that angular speed for said rewind roll which is necessary to maintain constant the lineal speed of said web as it is rewound, and wherein said system includes

a. means for producing a reference signal,

b. means for algebraically combining said speed and reference signals into a resultant signal, and

c. means for applying said resultant signal to said means for driving the said clutch input member in response thereto.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,603,521 Dated September 7, 1971

Inventor(s) Thomas R. Ormsby

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 47, insert "clutch" before -- couplings --.
Column 6, line 34, Claim 9 (b), after "signal" the following line should be inserted -- proportional to the end face area constant comprising --.
Column 6, line 61, after "coupling" insert -- of --.

Signed and sealed this 9th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents