March 19, 1963 M. W. KRON 3,081,961

TENSION CONTROL DEVICE

Filed Oct. 12, 1960 4 Sheets-Sheet 1

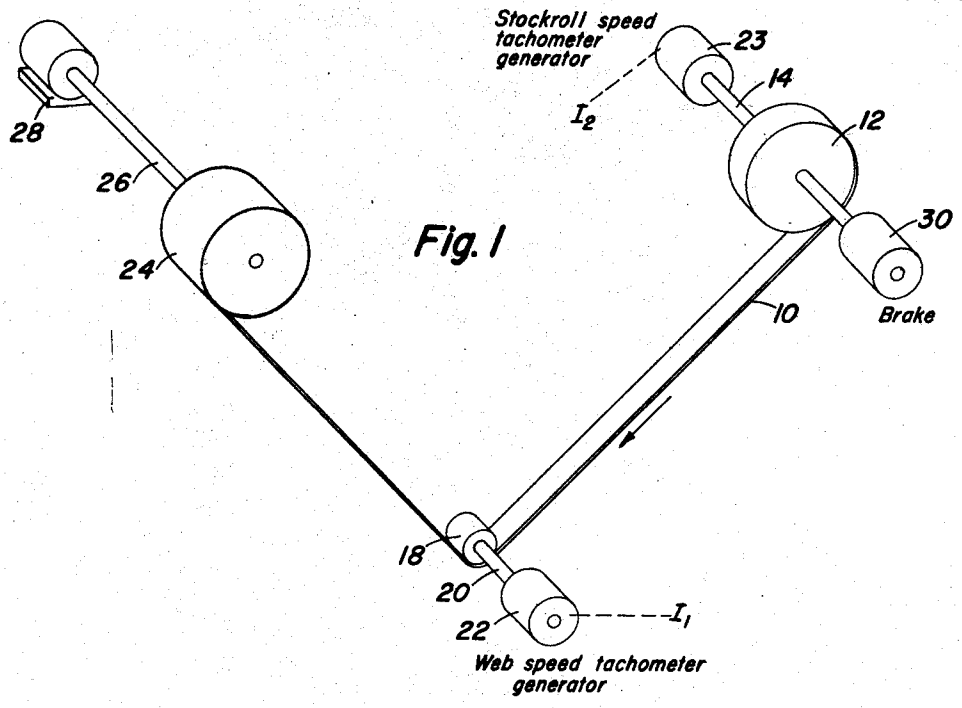
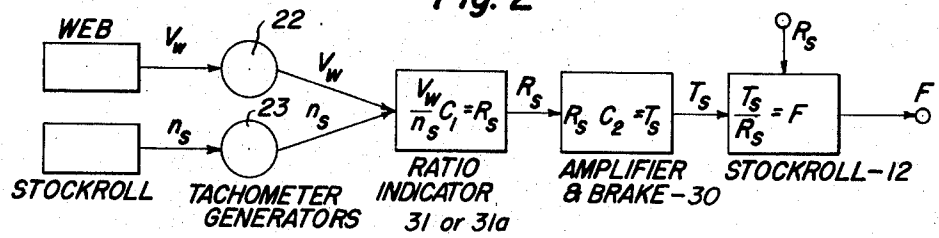


Fig. 1

Fig. 2



MARTIN W. KRON
INVENTOR.

BY R Frank Smith
Robert W. Hampton
ATTORNEYS

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Fig. 3

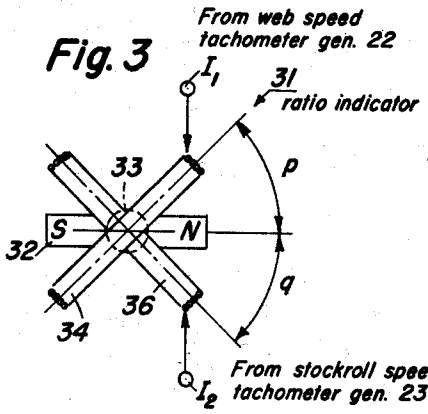
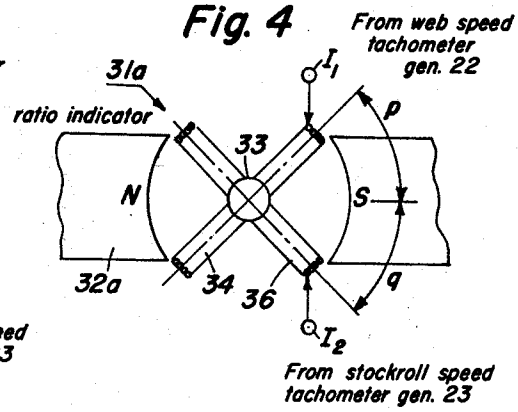


Fig. 4



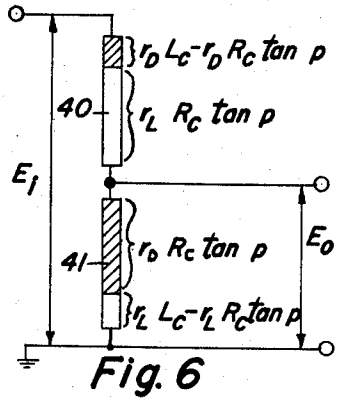
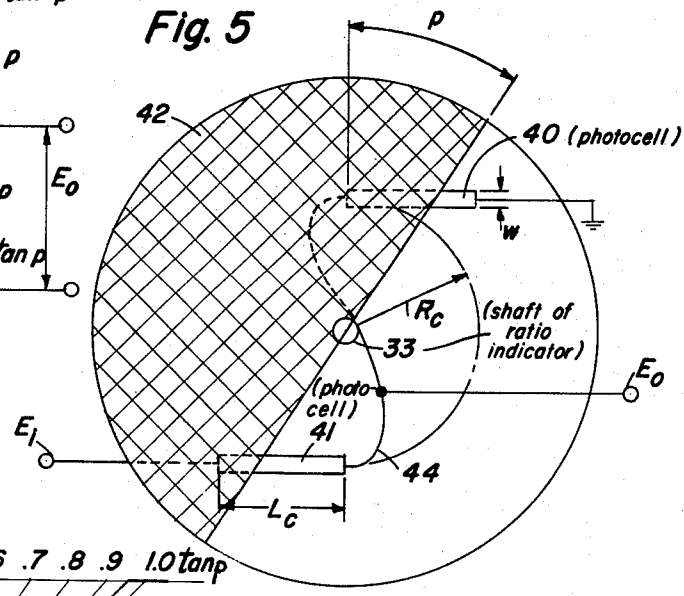


Fig. 6

Fig. 5



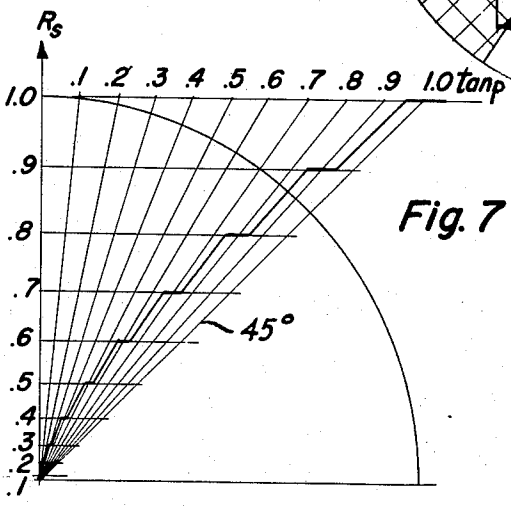


Fig. 7

MARTIN W. KRON
INVENTOR.

BY R Frank Smith
Robert W Hampton
ATTORNEYS

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Fig. 8

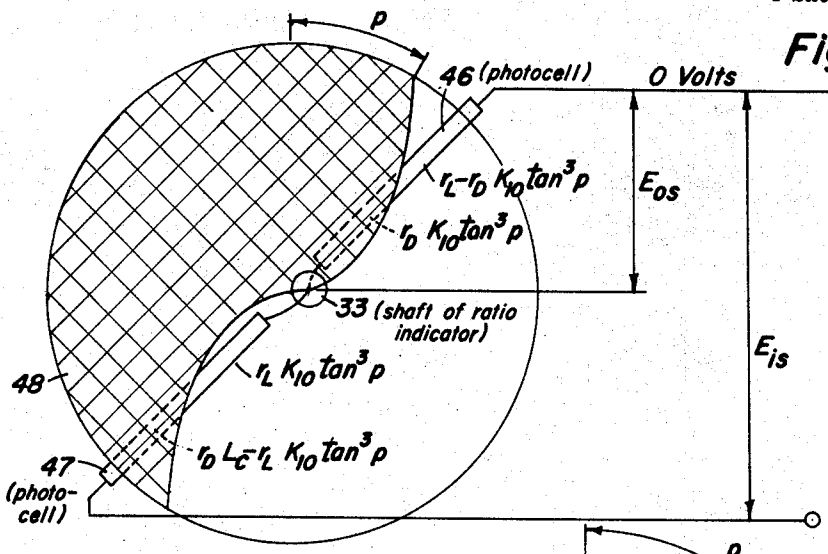


Fig. 9

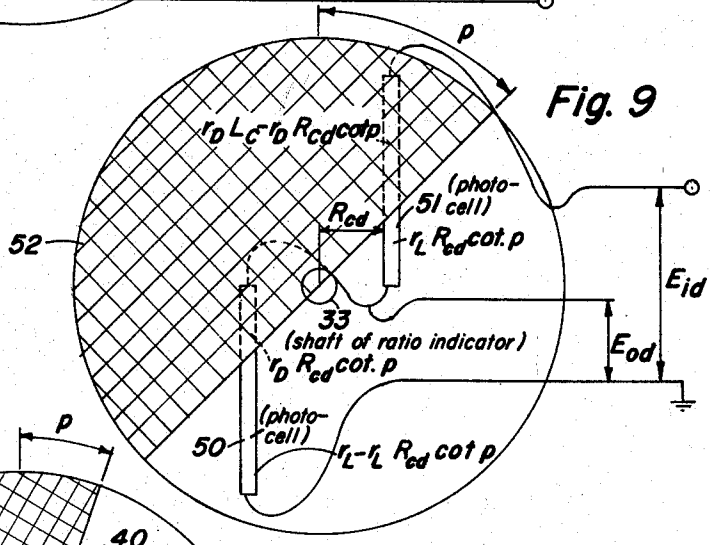
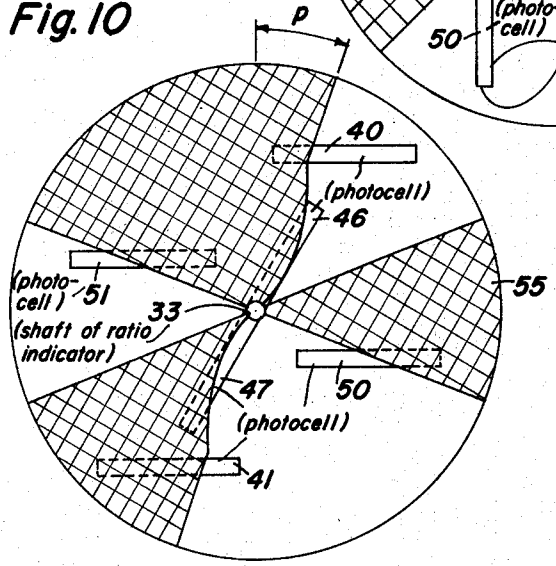


Fig. 10



MARTIN W. KRON
INVENTOR.

BY R Frank Smith
Robert W. Hampton
ATTORNEYS

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Fig. 11

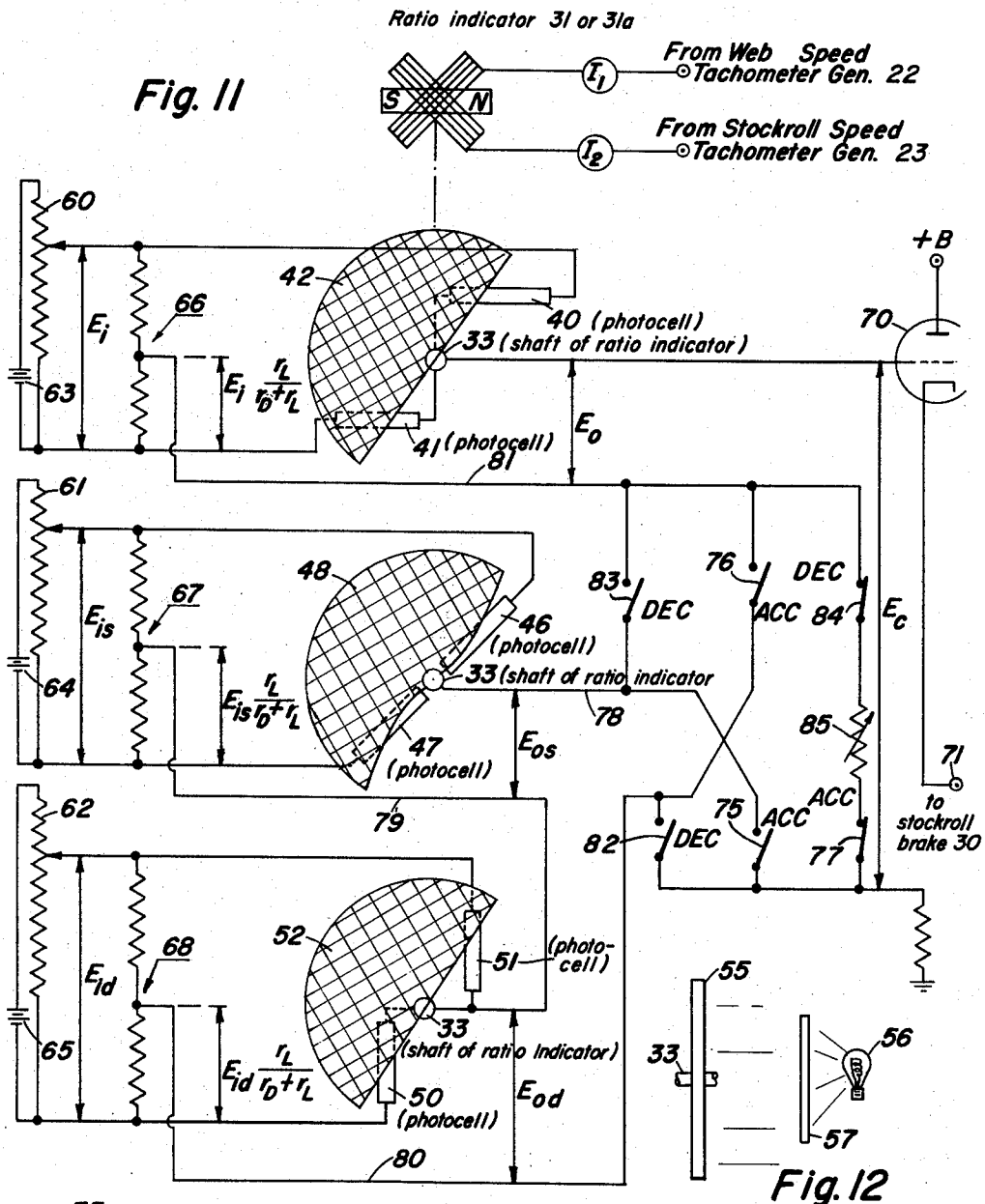
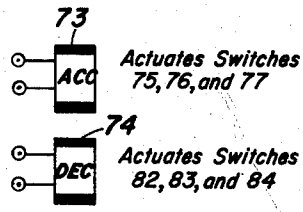


Fig. 12



MARTIN W. KRON
INVENTOR.

BY R Frank Smith
Robert W. Hampton
ATTORNEYS

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Patented Mar. 19, 1963

3,081,961

TENSION CONTROL DEVICE

Martin W. Kron, Rochester, N.Y., assignor to Eastman Kodak Company, Rochester, N.Y., a corporation of New Jersey

Filed Oct. 12, 1960, Ser. No. 62,153
12 Claims. (Cl. 242—75.47)

The present invention relates to the art of web winding and unwinding and more particularly concerns an improved method and apparatus for controlling web tension.

In controlling the tension of a web of material being unwound from a stockroll, the radius of the stockroll must be considered, because with a given braking torque on the stockroll the unwind tension is inversely related to the stockroll radius. In one prior art method of controlling the unwind web tension, the actual web tension is measured, for example by means of a dancer roll cooperating with the web. The tension measurement is converted into a first signal, which is compared to a reference signal to generate an error signal; the error signal is then fed back to a stockroll brake. Although the dancer roll method provides accurate tension control, it requires an expensive device for directly measuring web tension and it generally requires the use of one or more rollers in addition to the usual guide or idling rollers in contact with the web. Delicate webs such as those carrying photographic emulsions tend to be damaged by contact with rollers of any but the most expensive kinds; therefore, the use of rollers must be minimized in any winding or unwinding apparatus for such webs. Furthermore, the dancer roll method appears to be inapplicable to apparatus for slitting webs, because no practical means is known for directly measuring the unwind web tension on slitters.

In a second prior art method of controlling web tension, the stockroll brake torque is controlled in proportion to the stockroll radius, with or without direct feedback. In employing this second method a difficulty lies in measuring the stockroll radius. For this purpose, an additional roller riding on the stockroll is objectionable in most cases because it might damage the web and tends to interfere with loading and unloading the stockroll stand. In accordance with the present invention the stockroll radius is computed from two input signals representing linear web speed and angular stockroll speed, respectively. Computation is done by means of a tachometer generator and an arrangement of photocells used as a ratio indicator whose output is proportional to the ratio of the two input signals and thus proportional to stockroll radius. This output is employed to control brake torque on the stockroll for conditions of substantially constant web speed. During constant acceleration or deceleration of the stockroll the ratio indicator also is employed to generate a second signal proportional to the third power of the stockroll radius and a third signal inversely proportional to the stockroll radius, which signals are applied to the stockroll brake to compensate for stockroll inertia and inertia of the brake drive elements.

In a preferred embodiment the above mentioned ratio indicator rotates one or more shaped masks that are positioned between a light source and a system of photoelectric detectors. The outputs from the detectors constitute the three control signals for the brake.

It is therefore a principal object of the invention to control the unwind tension of a web by means of apparatus that requires no additional contact with the web.

Another object of the invention is to maintain the tension of a web substantially constant during constant-speed movement of the web and during constant-rate acceleration or deceleration thereof.

A further object of the invention is to employ a tachometer generator and an arrangement of photocells as a ratio indicator to generate a signal that is a function of the stockroll radius.

Other objects of the invention are:

To generate a signal representing the inverse of the stockroll radius;

To generate a signal representing the third power of the stockroll radius;

To compensate for stockroll inertia during constant-rate acceleration or deceleration of an unwinding web;

To compensate for brake-system inertia during acceleration or deceleration of an unwinding web; and

To employ a system of photoelectric detectors in conjunction with a light source and a web-controlled mask for generating a signal that is a predetermined function of stockroll radius.

Other objects of the invention will appear from the following description, reference being made to the accompanying drawings, wherein:

FIG. 1 is a perspective view of a winding and unwinding apparatus in which the present invention may be employed;

FIG. 2 is a schematic flow diagram of the tension control system for constant web speed, according to the invention;

FIG. 3 illustrates one form of a ratio indicator;

FIG. 4 illustrates a second form of ratio indicator;

FIG. 5 is a front view of an arrangement of mask and photoelectric detectors employed for generating a signal representing stockroll radius;

FIG. 6 is a schematic view of the photoelectric detectors of FIG. 5, illustrating the signal generated thereby;

FIG. 7 is a chart showing the derivation of a masking outline for a detector employed to generate a signal representing the third power of stockroll radius;

FIG. 8 is a front view of an arrangement of mask and photoelectric cells employed for generating a signal representing the third power of stockroll radius;

FIG. 9 is a front view of an arrangement of mask and photoelectric cells employed for generating a signal representing the inverse of stockroll radius;

FIG. 10 is a front view of a composite arrangement of the masks and photoelectric detectors shown in FIGS. 5, 7 and 8;

FIG. 11 is a schematic wiring diagram of the overall tension control system; and

FIG. 12 is a schematic side view of a typical light source and detector according to the invention.

Constant Web Speed

Referring to FIGS. 1 and 2, the latter of which illustrates the basic tension control system for constant web speed, a web **10** is unwound from a stockroll **12** mounted on a shaft **14**, which rotates with the stockroll. An electrically controlled brake **30** provides and controls web tension. The web is guided in any desired manner by idler rollers represented in general by a roller **18** shown in FIG. 1. This roller is mounted on a shaft **20**, which is rotated with roller **18**. The web is collected on a wind-up roller **24**, which is driven through a shaft **26** by an electric motor **28**. The brake **30** has an output torque that is independent of the speed of shaft **14**, but can be controlled by controlling the current in the brake winding. The "Magnebrake" manufactured by Vickers Corporation is an example of a brake having the above characteristics.

The tension control system according to the invention uses a ratio indicator whose output is proportional to the ratio of two inputs. When these inputs are proportional to web speed V_w and rotational stockroll speed n_s, the

output R_s indicates the stockroll radius in accordance with the following equation:

$$R_s=\frac{V_w}{2\pi n_s} \quad (1)$$

Equation 1 holds true for any unwinding speed within the capability of the system elements. The output of the ratio indicator is amplified and converted by linear elements into a stockroll brake torque directly proportional to the stockroll radius, the prerequisite for constant unwind tension at a constant web speed. In FIG. 2,

C_1, C_2=Constants
T_s=Stockroll brake torque
F=Web tension

A first direct current tachometer generator **22** may be driven by shaft **20** of idler roller **18**, as shown in FIG. 1, and generates a direct current output whose magnitude is proportional to web speed V_w. A second tachometer generator **23** is driven by the stockroll shaft **14** and generates a direct current signal whose magnitude is proportional to the angular stockroll speed n_s. The D.C. tachometer generators may be of any well known type, for example "Elinco No. 183."

The ratio indicator **31** or **31***a* (FIGS. 3 and 4) comprises a permanent magnet **32** or **32***a* and two crossed coils **34** and **36** forming the angles p and q with the axis of the permanent magnet. Either the magnet or the two coils may be pivoted. FIG. 3 shows the magnet **32** as pivoted about a shaft **33** inside the coils; FIG. 4 shows the coils pivoted together between the arms of an external magnet **32***a*. The coils **34** and **36** receive currents I_1 and I_2 from the respective generators **22** and **23** (FIG. 1) and, interacting with the permanent magnet field, exert the torques T_1 and T_2 on the pivoting member or members.

$$T_1=BCI_1 \cos p \quad (2)$$

$$T_2=BCI_2 \cos q \quad (3)$$

where B and C are constants of magnetic field and instrument characteristic, respectively. The pivoting member or members move into the posititon where $T_1=T_2$. Taking $p+q=\beta$, the balanced instrument position results as:

$$\frac{I_1}{I_2}=\frac{\cos q}{\cos p}=\frac{\cos(\beta-p)}{\cos p} \quad (4)$$

$$=\cos\beta+\sin\beta\tan p \quad (5)$$

$$=K_1+K_2\tan p \quad (6)$$

where K_1 and K_2 are constants. Therefore the instrument indicates the ratio I_1 over I_2 as a tangent function of the angle p. Since I_1 and I_2 are proportional to web speed V_w and rotational stockroll speed n_s, respectively, the instrument indicates the stockroll radius R_s as:

$$R_s=\frac{V_w}{2\pi n_s}=\frac{C_3I_1}{C_4I_2}=K_3+K_4\tan p \quad (7)$$

where C_3, C_4, K_3 and K_4 are constants.

A standard two phase, two pole A.C. tachometer generator with a permanent magnet rotor may be used as a ratio indicator. The coils are displaced by an angle $\beta=p+q=90°$. With $\cos\beta=0$, K_1 and K_3 are 0. With $\sin\beta=1$, K_2 is 1. The rotor shaft then indicates the stockroll radius as

$$R_s=K_4\tan p \quad (8)$$

$K_4\tan p$ has to be transformed into an electrical output signal. The torque available in the final position of shaft **33** of ratio indicator **31** or **31***a* is substantially zero and is not capable of moving an electro-mechanical element such as a potentiometer or variable linear differential transformer. A photoelectric transducer is employed instead.

Referring to FIG. 5, two long, narrow photocells **40** and **41** are placed tangential to a circle of radius R_c concentric with the indicator shaft **33**. The cells are illuminated by a light source **56** (FIG. 12) and are partially covered by a disk **42**, which is partly opaque and partly transparent and is fastened to the shaft **33** for angular movement therewith. With the two cells connected in series by a lead **44** and an input voltage E_1 applied to their remote ends (see also FIG. 6) an output signal E_o proportional to tan p is obtained off the center connection.

If:
E_1=Input voltage to photocells
E_o=Output voltage off center connection of photocells
r_D=Dark resistance per unit length of photocell
r_L=Light resistance per unit length of photocell
L_c=Length of photocell
w=Width of photocell
R_c=Radius of circle to which both photocells are tangent

and if w is negligible realtive to R_c, the following equation can be written according to FIG. 6:

$$\frac{E_o}{E_i}=\frac{r_DR_c\tan p+r_LL_c-r_LR_c\tan p}{r_LL_c-r_LR_c\tan p+r_DR_c\tan p} \quad (9)$$
$$+r_LR_c\tan p+r_DL_c-r_DR_c\tan p$$

$$=\frac{r_LL_c+(r_D-r_L)R_c\tan p}{(r_D+r_L)L_c} \quad (10)$$

$$=\frac{r_L}{r_D+r_L}+\frac{(r_D-r_L)R_c}{(r_L+r_D)L_c}\tan p \quad (11)$$

$$=K_5+K_6\tan p, \quad (12)$$

where K_5 and K_6 are constants.

Substituting

$$\tan p=\frac{R_s}{K_4}$$

(Equation 8) we obtain the output signal E_o as a linear function of the stockroll radius R_s.

$$E_o=E_iK_5+\frac{E_iK_6}{K_4}R_s=E_i(K_5+K_7R_s) \quad (13)$$

where

$$K_7=\frac{K_6}{K_4}$$

The output E_o of the photocells **40** and **41** is amplified and applied to the stockroll brake **30** (FIG. 1) as hereinafter described.

Acceleration and Deceleration

The brake torque required on the stockroll shaft to hold the unwind web tension constant during changes in web speed is given by the equation

$$T=FR_s-J_s\alpha_s-J_d\alpha_d \quad (14)$$

where

T=Stockroll brake torque
F=Unwind web tension (force)
J_s=Moment of inertia of stockroll
α_s=Angular acceleration of the stockroll, and is negative during deceleration
J_d=Moment of inertia of the stockroll brake drive elements
α_d=Angular acceleration of stockroll brake drive elements, and is negative during deceleration

The product FR_s is the torque required to hold the web tension F constant while the web **10** runs at constant speed. $J_s\alpha_s$ and $J_d\alpha_d$ are torques required to accelerate the stockroll and brake-drive inertias when the web speed changes. The present invention includes means for controlling the stockroll brake automatically to compensate for these torques and to maintain the unwind web tension substantially constant.

If the angular accelerations of the brake drive elements

such as gears, shafts, rotating brake member, etc., are referred to the stockroll shaft we obtain:

$$\alpha_s=\alpha_d=\alpha \tag{15}$$

Furthermore, α can be expressed as:

$$\alpha=\frac{a}{R_s} \tag{16}$$

where a=rate of acceleration of the web.

The compensating torques $J_s\alpha$ and $J_d\alpha$ are then expressed as functions of R_s by Equations 17 and 18.

$$J_s\alpha=\tfrac{1}{2}\frac{\gamma}{g}\pi L_s R_s^4\frac{a}{R_s} \tag{17}$$

where

γ=specific weight of web material
g=acceleration due to gravity
L_s=length of stockroll (width of web)

$$J_d\alpha=J_d\frac{a}{R_s} \tag{18}$$

With the rate of acceleration a constant we obtain:

$$\tfrac{1}{2}\frac{\gamma}{g}\pi L_s a=K_8 \tag{19}$$

where K_8 is a constant.

$$J_d a=K_9 \tag{20}$$

where K_9 is a constant.

Substituting Equations 17, 18, 19 and 20 in Equation 14, the latter becomes:

$$T=FR_s\mp K_8R_s^3\mp K_9\frac{1}{R_s} \tag{21}$$

where a minus sign corresponds to acceleration and a plus sign to deceleration.

Equation 21 shows that two compensating torque components are required for controlling tension during substantially constant acceleration and deceleration, in addition to the one required during constant web speed. One of these additional torque components must be proportional to the third power of the stockroll radius (R_s^3), the other inversely proportional to the stockroll radius

$$\left(\frac{1}{R_s}\right)$$

The ratio indicator **31** (FIG. 3) combined with a photoelectric detector (FIG. 5), described above, has an output proportional to R_s:

$$\frac{E_o}{E_i}=\frac{r_L}{r_D+r_L}+\frac{(r_D-r_L)R_cR_s}{(r_D+r_L)L_cK_4} \tag{22}$$

In order to obtain the desired additional functions, the same basic system of detecting R_s is used, but the radius R_c is changed from a constant to a variable radius R_{cs}:

$$R_{cs}=K_{10}\tan^2 p \tag{23}$$

where K_{10} is a constant.
This results in:

$$\frac{E_{os}}{E_{is}}=\frac{r_L}{r_D+r_L}+\frac{(r_D-r_L)K_{10}}{(r_D+r_L)L_c(K_4)^2}R_s^3 \tag{24}$$

where

E_{is}=Input voltage to photocell detector for compensating stockroll inertia.
E_{os}=Output voltage at center connection of photocell detector.

The physical arrangement of the photocells according to Equation 23 results in a large number of photocells arranged in a curved pattern and a straight dividing line of opaque and transparent sections of a mask, as illustrated in the chart of FIG. 7. If the photocells are turned clockwise to the 45° line and the corresponding points on the mask dividing line are turned through the same angle, an arrangement, illustrated in FIG. 8, results with two straight photocells **46** and **47** and a disk **48** having a curved, generally cyma-shaped line separating its transparent zone from its opaque zone according to Equation 24. In this embodiment the variable radius R_{cs} is the distance from the axis of shaft **33** to the intersection of the disk **48** with the photocells **46** or **47**.

To compensate for inertia of the brake drive elements one of the detectors must have an output proportional to

$$\frac{1}{R_s}$$

The output of the detector shown in FIG. 5 is proportional to

$$p=\frac{R_s}{K_4}$$

(Equation 8), the inverse of what is required. If the cotangent is measured instead, we obtain the desired output.

$$\cot p=\frac{1}{\tan p}=\frac{K_4}{R_s} \tag{25}$$

The detector transfer function is then:

$$\frac{E_{od}}{E_{id}}=\frac{r_L}{r_D+r_L}+\frac{(r_D-r_L)R_{cd}K_4}{r_L+r_DL_cR_s} \tag{26}$$

where

E_{id}=Input voltage to photocell detector for compensating brake drive inertia.
E_{od}=Output at center connection of photocell detector.
R_{cd}=Radius of circle to which photocells are cotangent.

An arrangement of two photocells **50** and **51** and a partially transparent disk **52** with the corresponding borderline, according to Equation 26, is shown in FIG. 9.

The three previously described detectors, shown in FIGS. 5, 8 and 9, may be combined so that they employ only one partially transparent disk and one light source. This arrangement of the six photocells and a disk **55**, which is fastened to shaft **33**, is shown in FIG. 10.

The single light source **56** is provided to illuminate all photocells and is placed a few inches in front of the center of disk **55**, as shown in FIG. 12. A diffuser **57** may be interposed between the light source **56** and disk **55**, which is fastened to shaft **33**.

The output voltages of the three photocell detectors are:

$$E_o=E_i\frac{r_L}{r_D+r_L}+E_i\frac{(r_D-r_L)R_cR_s}{(r_D+r_L)L_cK_4} \tag{27}$$

$$E_{os}=E_{is}\frac{r_L}{r_D+r_L}E_{is}\frac{(r_D-r_L)K_{10}R_s^3}{(r_D+r_L)L_cK_4^3} \tag{28}$$

$$E_{od}=E_{id}\frac{r_L}{r_D+r_L}+E_{id}\frac{(r_D-r_L)R_{cd}K_4}{(r_D+r_L)L_cR_s} \tag{29}$$

If the product

$$E_i\frac{r_L}{r_D+r_L},E_{is}\frac{r_L}{r_D+r_L}$$

or

$$E_{id}\frac{r_L}{r_D+r_L}$$

is subtracted from each side of the corresponding Equation 27, 28 or 29, and these equations are multiplied by the transfer constant A of the amplifier and brake system, we can substitute the right sides of these equations for the products on the right side of Equation 21 and obtain:

$$\begin{aligned}T=&E_iA\frac{(r_D-r_L)R_cR_s}{(r_D+r_L)L_cK_4}\\&\mp E_{is}A\frac{(r_D-r_L)K_{10}R_s^3}{(r_D+r_L)L_cK_4}\\&\mp E_{id}A\frac{(r_D-r_L)R_{cd}K_4}{(r_D+r_L)L_cR_s}\end{aligned} \tag{30}$$

FIG. 11 shows a schematic electrical wiring diagram of the overall system for solving Equations 30. The three input voltages E_i, E_{is}, and E_{id} are taken from respective potentiometers **60**, **61** and **62** connected to independent voltage supplies, **63**, **64** and **65**. The voltages

$$E_i\frac{r_L}{r_D+r_L}, E_{is}\frac{r_L}{r_D+r_L}$$

and

$$E_{id}\frac{r_L}{r_D+r_L}$$

are taken from respective voltage dividers **66**, **67** and **68** across the inputs and are subtracted from the outputs of the corresponding pairs of photocells. The output E_o is fed through an amplifier **70**, shown as a cathode follower amplifier with output **71**, and through additional amplifiers if required to the winding of the stockroll brake **30** (FIG. 1). The outputs E_{os} and E_{od} (FIG. 11) are either subtracted from (during acceleration) or added to (during deceleration) the signal E_o. This addition or subtraction is accomplished under the control of two relays **73** and **74**, energized during acceleration periods and during deceleration periods, respectively, as described below. The compensated output signal

$$E_c=E_o\mp E_{os}\mp E_{od} \quad (31)$$

is fed to the previously described amplifier **70** and after sufficient amplification to the brake **30** (FIG. 1).

During acceleration, relay **73** (FIG. 11) is operated and closes two pairs of contacts **75** and **76** and opens a pair of contacts **77**. The compensated output circuit, starting from ground, extends through contacts **75**, a lead **78**, the detector comprising photocells **46** and **47**, a lead **79**, the detector comprising photocells **50** and **51**, a lead **80**, contacts **76**, a lead **81**, the detector comprising photocells **40** and **41**, and amplifier **70** to output **71**. The polarity of the bottom two detectors in FIG. 11 is such that through the above circuit the outputs E_{os} and E_{od} are subtracted from E_o.

During deceleration, relay **74** is operated and closes two pairs of contacts **82** and **83** and opens a pair of contacts **84**. The compensated output circuit from ground extends through contacts **82**, lead **80**, the detector comprising photocells **50** and **51**, lead **79**, the detector comprising photocells **46** and **47**, lead **78**, contacts **83**, lead **81**, the detector comprising photocells **40** and **41**, and amplifier **70** to terminal **71**. It will be seen that the direction of current flow through the bottom two detectors of FIG. 11 is reversed to that during acceleration, so that E_{os} and E_{od} are added to, rather than subtracted from, E_o.

During constant speed operation, neither of the relays **73** and **74** is operated; therefore, contacts **75**, **76**, **82** and **83** are all open, but contacts **77** and **84** are both closed. The latter two contacts are in series with each other and with a variable resistor **85**. When contacts **77** and **84** are both closed they ground lead **81**, which is one of the output leads of the detector comprising photocells **40** and **41**; therefore only the output E_o is fed directly to the amplifier **70**. The bottom two detectors of FIG. 11 are disconnected from the amplifier by the contacts **75** and **76** or by contacts **82** and **83**. During acceleration or deceleration, either contacts **77** or contacts **84** are open, thereby interrupting the direct connection of E_o to the amplifier **70**.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modification can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

I claim:

1. Apparatus for controlling the tension of a web of material being unwound from a stockroll, comprising in combination: first sensing means for sensing the linear web speed; first generating means controlled by said first sensing means for generating a first signal proportional to linear web speed; second sensing means for sensing the angular stockroll speed; second generating means controlled by said second sensing means for generating a second signal proportional to the angular stockroll speed; third generating means coupled to said first and second generating means for generating a third signal which is a function of the ratio of said first and second signals and therefore a function of the instantaneous radius of said stockroll; braking means coupled to said stockroll for applying a braking torque to said stockroll in proportion to the energization of said braking means; and means interconnecting said third generating means and said braking means for energizing said braking means as a function of the magnitude of said third signal.

2. The apparatus defined in claim 1, wherein said third generating means comprises: a ratio-responsive device having inputs from said first and second generators and having a movable member angularly positioned about an axis as a function of the ratio of said first and second signals; a photoelectric detector having an output connected to said braking means; and a mask connected to said movable member and angularly positioned therewith about said axis, said mask having a path of movement between a light source and said detector for variably shielding said detector from said light source, whereby said brake is variably energized by said detector as a function of the ratio of the magnitudes of said first and second signals.

3. The apparatus defined in claim 2, wherein said detector comprises a pair of elongated photoelectric cells electrically connected in series with each other, with a source of electrical energy and with said braking means, said cells being disposed substantially parallel to each other and to a plane normal to the axis of angular movement of said mask, said cells being further disposed symmetrically about said axis in mutually offset relation, said mask comprising an opaque member having a substantially straight edge passing through said axis, whereby said detector energizes said braking means substantially in proportion to the instantaneous stockroll radius.

4. The apparatus defined in claim 2, wherein said detector comprises a pair of elongated photoelectric cells electrically connected in series with each other, with a source of electrical energy and with said braking means, said cells being disposed substantially parallel to each other and to a plane normal to the axis of angular movement of said mask, said cells being further disposed symmetrically about said axis and in a plane containing said axis, said mask comprising an opaque member having a cyma-shaped edge passing through said axis, whereby said detector energizes said braking means substantially in proportion to the cube of the instantaneous stockroll radius.

5. The apparatus defined in claim 2, wherein said detector comprises a pair of elongated photoelectric cells electrically connected in series with each other, with a source of electrical energy and with said braking means, said cells being disposed substantially parallel to each other and to a plane normal to the axis of angular movement of said mask, said cells being further disposed symmetrically about said axis in mutually offset relation, said mask comprising an opaque member having a substantially straight edge passing through said axis, whereby said detector energizes said braking means substantially in inverse proportion to the instantaneous stockroll radius.

6. Apparatus for controlling the tension of a web of material being unwound from a rotating stockroll, comprising in combination: an idler roller for said web; a shaft supporting said stockroll and adapted to rotate therewith; first and second generators driven by said idler roller and said stockroll shaft, respectively, for generating first and second signals proportional, respectively, to

linear web speed and to angular stockroll speed; a ratio-responsive device having respective inputs from said first and second generators and generating a third signal as a function of the ratio of said first and second signals; a brake coupled to said stockroll shaft and connected to said ratio-responsive device for receiving said third signal and for applying a braking torque to said stockroll shaft in proportion to the magnitude of said third signal.

7. Apparatus for controlling the tension of a web of material being unwound from a stockroll, comprising in combination: first generating means for generating a first signal proportional to the instantaneous stockroll radius; second generating means for generating a second signal proportional to the cube of the instantaneous stockroll radius; a brake coupled to said stockroll for applying a braking torque thereto in proportion to the energization of said brake; means connecting said first generating means to said brake for constantly energizing the latter in proportion to the magnitude of said first signal; and means operable during a change of angular stockroll speed for combining said second signal with said first signal, whereby said brake is energized as a joint function of the magnitudes of said first and second signals.

8. Apparatus for controlling the tension of a web of material being unwound from a stockroll, comprising in combination: first generating means for generating a first signal proportional to the instantaneous stockroll radius; second generating means for generating a second signal proportional to the cube of the instantaneous stockroll radius; third generating means for generating a signal inversely proportional to the instantaneous stockroll radius; a brake coupled to said stockroll for applying a braking torque thereto in proportion to the energization of said brake; means connecting said first generating means to said brake for constantly energizing the latter in proportion to the magnitude of said first signal; and means operable during a change of angular stockroll speed for combining said second and third signals with said first signal, whereby said brake is energized as a joint function of the magnitudes of said first, second and third signals.

9. The method of controlling tension in a web of material being unwound from a stockroll, comprising: applying to said stockroll a primary braking torque when said web is moving at substantially constant speed, said primary braking torque being proportional to the instantaneous stockroll radius; and reducing said primary braking torque by an increment when said web is accelerating, said increment being proportional to the cube of the instantaneous stockroll radius.

10. The method defined in claim 9, with the additional step of increasing said primary braking torque by said increment when said web is decelerating.

11. The method of controlling tension in a web of material being unwound from a stockroll, comprising: applying a primary braking torque to said stockroll when said web is moving at substantially constant speed, said primary braking torque being proportional to the instantaneous stockroll radius; and reducing said primary braking torque by first and second increments when said web is accelerating, said first increment being proportional to the cube of instantaneous stockroll radius, said second increment being inversely proportional to stockroll radius.

12. The method defined in claim 11, with the additional step of increasing said primary braking torque by said first and second increments when said web is decelerating.

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