Dec. 19, 1967 F. BELANGER ET AL 3,358,893

APPARATUS FOR UNIFORMLY MOVING A WEB PAST A SPECIFIC POINT

Filed July 13, 1965

3 Sheets-Sheet 1

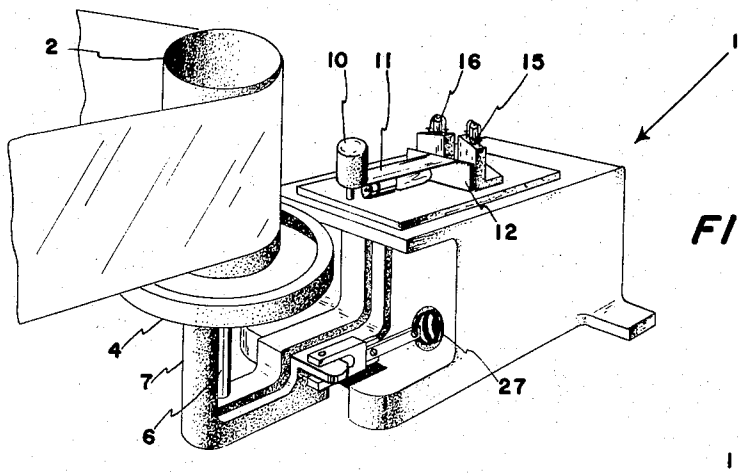


FIG.—1

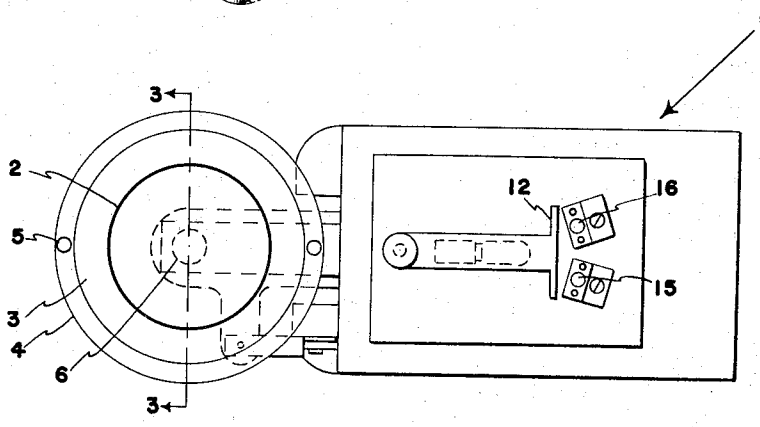


FIG.—2

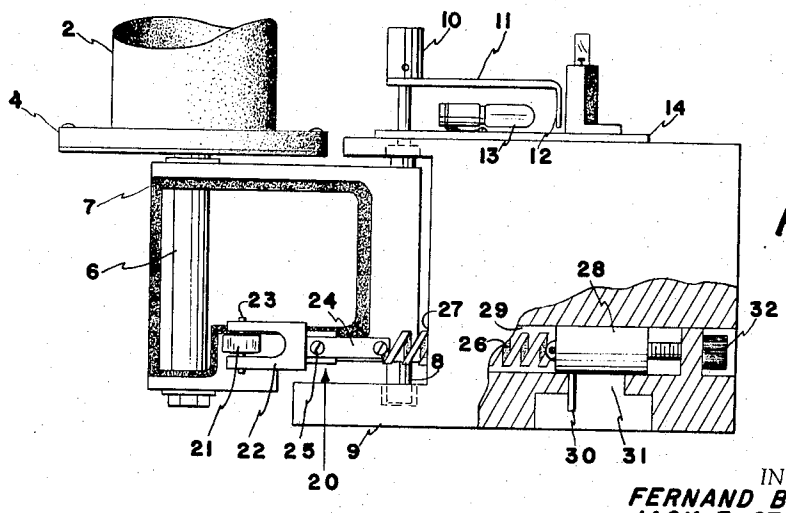


FIG.—3

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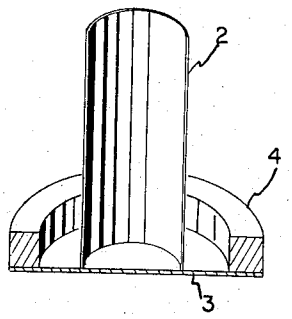


FIG.-4

FIG.-5

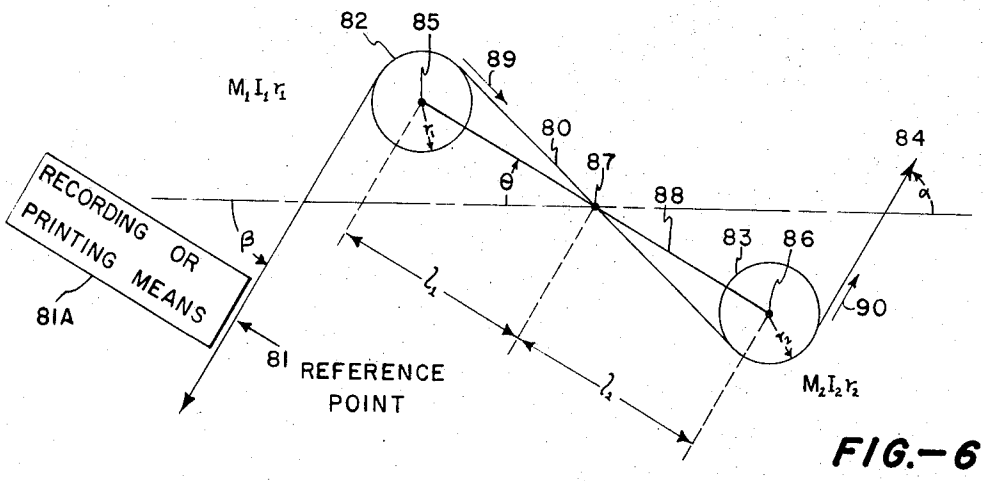


FIG.-6

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APPARATUS FOR UNIFORMLY MOVING A WEB PAST A SPECIFIC POINT

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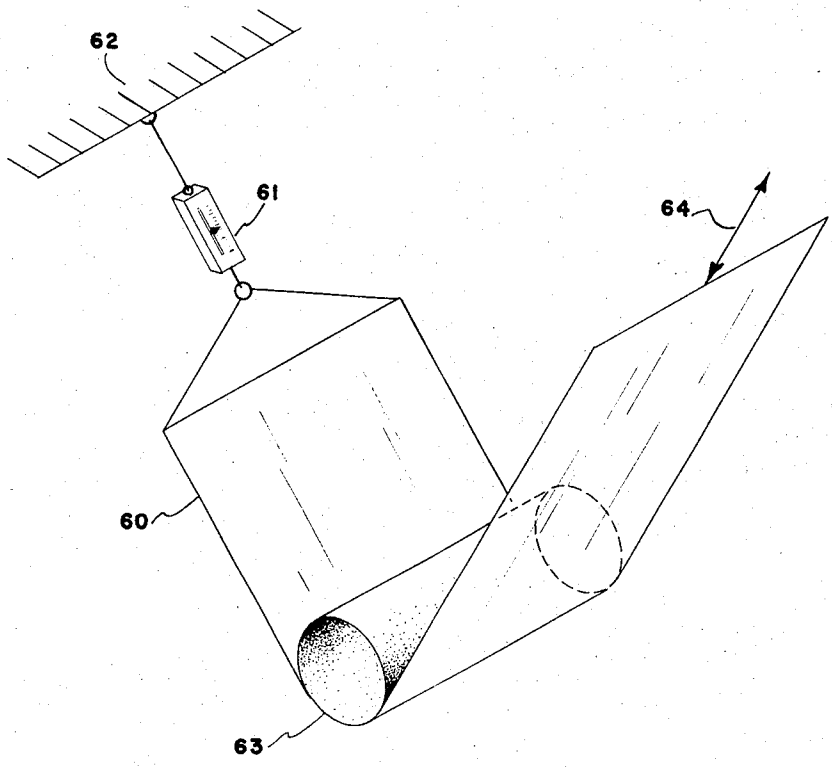


FIG.—7

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APPARATUS FOR UNIFORMLY MOVING A WEB PAST A SPECIFIC POINT

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10 Claims. (Cl. 226—195)

ABSTRACT OF THE DISCLOSURE

An apparatus for uniformly moving a film or web past a reference point, and more specifically a unique roller concept which is positioned between a reference point and a take-up means for the web which substantially eliminates all disturbances normally associated with the take-up means whereby the roller is of such specification and construction that the torque result from the film tension times the radius of the spool times the mass of the spool is substantially equal and opposite to a torque caused by the mass of the spool times its radius of gyration. Specifically, the radius of gyration of the roller can be adjusted by removable disc means being added to or taken away from the base of the roller.

This invention relates to an apparatus for uniformly moving a film or web past a reference point, and more specifically to a unique roller concept which is positioned between a reference point and a take up means for a web, and which roller substantially eliminates all disturbances normally associated with the take up means and external disturbances that heretofore have been translated back through the web to the reference point.

Heretofore, it has been well known that there have been many and varied means to effect uniform movement of webs, particularly where printing, either of ink or photography is being done to the web. Obviously, when such printing is being done, the uniform movement of the web is an absolute necessity or blurring, smearing, or other defficiencies will exist. One of the big problems in uniform movement of webs has been that the normal vibrations or disturbances caused by the moving mechanism is translated back through the web to the point where printing or other processes are being applied to the moving web. Further, the normal problems associated with moving webs are materially increased when it is desired to utilize such apparatus in an aircraft, or other moving objects subject to pitch, yaw, or roll, as these external forces also tend to cause further disturbances to the web at the reference or printing point. With a great degree of resolution and exact focusing being required for accurate aerial reconnaissance photographing from a moving aircraft, it becomes extremely critical that a moving web of film be provided with a known constant relative movement regardless of disturbances caused by the take up mechanism, or external forces caused because of location of the apparatus in an airborne vehicle. An apparatus is needed to insure uniform movement of a web past a specific reference point regardless of the normal disturbances caused by take up mechanism, or any external disturbances.

Therefore, it is the general object of the present invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices and to meet the needs of the art by providing a roller apparatus which acts as a buffer on a web moving therearound between a reference point on the web in front of the roller and take up means for the web behind the roller so that the movement of the web past the reference point is uniformly constant.

A further object of the invention is to provide a simple,

inexpensive, yet highly effective roller apparatus which will insure uniform movement of a web moving therearound past a reference point therebefore.

A further object of the invention is to provide a roller apparatus which will provide uniform movement of a web moving therearound past a reference point therebefore regardless of disturbances caused by take up mechanism, or any external forces.

A further object of the invention is to provide a roller apparatus for passing a web therearound whereby the torque resultant from the film tension times the radius of the spool times the mass of the spool is substantially equal and opposite to a torque caused by the mass of the spool times the radius of gyration which equalizing forces eliminate any disturbances caused in the film on the take up side of the roller from translating back through the web to the feeding side of the roller.

The aforesaid objects of the invention and other objects which will become apparent as the description proceeds are achieved by providing in an apparatus for moving a web past a reference point at a constant uniform speed the combination of a cylindrically shaped roller, means rotatably mounting the roller on the longitudinal axis thereof, a supporting frame, means pivotally mounting the means rotatably mounting the roller on the frame to allow substantially horizontal pivotal movement thereof, means to detect the pivotal relation of the roller relative to the frame, means to resiliently restrain with zero rate the horizontal pivotal movement of the frame, ring means operatively affixed to the roller so as to move the radius of gyration of the roller into substantial coincidence with the circumference defining the roller, an elongated web passed around the roller so that it contacts at least 90° of the circumference thereof and so that one end extends outwardly therefrom substantially perpendicular to the pivotal mounting means, means to uniformly pull the web from the one end to effect advancement around the roller, means on the other end of the web to restrain the movement thereof, and means positioned to print information on the web at a reference point before it reaches the roller.

For a better understanding of the invention reference should be had to the accompanying drawings, wherein:

FIGURE 1 is a perspective view, partially broken away, of the roller apparatus comprising one embodiment of the invention;

FIGURE 2 is a plan view of the roller apparatus of FIGURE 1;

FIGURE 3 is an elevational view in partial cross section of the roller apparatus of FIGURE 1;

FIGURE 4 is a perspective vertical cross sectional view of the roller alone, as taken substantially on line 3—3 of FIGURE 2;

FIGURE 5 is a schematic diagram of the angles and forces involved with a roller apparatus similar to that shown in FIGURE 1;

FIGURE 6 is a schematic diagram of the angles and forces involved using a double roller assembly still employing the principles of the invention; and

FIGURE 7 is a perspective illustration of another of the basic balance principles utilized in the invention.

While it should be understood that the principles of the invention are applicable to any moving web where it is desired to have uniform movement relative to a specific point, the invention is most readily adaptable to a moving film web in optical photographic equipment adapted for aerial reconnaissance, and hence it has been so illustrated and will be so described.

With reference to the form of the invention illustrated in FIGURE 2 of the drawings, the numeral 1 indicates generally a roller apparatus including a substantially cylindrically shaped roller 2, usually hollow, mounted on

a base plate 3. A weighted annular ring or solid disc 4 is mounted on the base plate 3 by any suitable means, such as bolts 5. The purpose of the ring 4, which comprises an important part of the invention, will be more fully described hereinafter. The base plate 3 is fixedly mounted on a shaft 6, as best seen in FIGURE 3, which shaft 6 is rotatably mounted in a carrying frame 7. The frame 7 is pivotally mounted by a pin 8 to a supporting base 9. It is anticipated that under normal circumstances the base 9 will be mounted horizontally so that both pins 6 and 8 will be vertically positioned in order that the roller 2 will rotate about the pin 6 on a vertical axis.

An upward extension 10 of the pin 8 has an arm 11 operatively secured thereto, which arm 11 has a downwardly and outwardly extending projection 12, as best seen in FIGURE 1. A light source 13 is operatively positioned to a top plate 14 of the base 9 which is adapted to actuate photosensitive cells 15 and 16. When the roller 2 and its support means is pivoted around the pin 8 because of some excessive forces, the arm 11 is caused to rotate moving the downward and outward projections 12 out of the way and causing the light 13 to actuate either of the photocells 15 or 16. The actuation of the photocells provides an indication and measurement of the force of movement of a film or web around the roller 2, and may be used to drive necessary equipment to control the tension or moving speed of the web, as desired.

In order to control the amount of pivotal swing which the roller 2 may take on the frame 7 about the pin 8, a resilient spring restraint, indicated generally by numeral 20 is provided. The restraint 20 includes an arm 21 formed as an integral part of the frame 7 and extending laterally or horizontally therefrom. A connecting link 22 is pivotally mounted to the arm by a pin 23, with a second connecting link 24 affixedly mounted to the link 22 by a suitable screw or bolt means 25. A helical coiled spring 26 is connected at one end to the wall of a hole 27 in the link 24 and at the other to an adjustable slide 28. The slide 28 is slidably carried in a bore 29 in the base 9, and is limited in its movement by an arm 30 slidably received in a slot 31. Adjustment of the longitudinal position of the slide 28 is achieved by a suitable adjusting screw 32 carried by the base 9, threadably screwed in the slide. Thus, adjustment of the screw 32 positions the slide 28 in the bore 29 and thereby increases or decreases the tension on the spring 26 making pivotal movement of the frame 7 more or less difficult. The adjustable pivotal resilience of the frame 7 is an important feature of the invention.

However, while the resilient restraint is necessary in a practical situation, it is only incidental to the principle of the invention. Thus, since the principle of the invention is to truly isolate one end of the film from the other, the spring 26 should have zero rate. In other words, the tension on the film should be independent of the position of the arm 7 shown in FIGURE 3. This is accomplished by the choice of spring 26, the particular geometry of the arm 7, and the attachment point of the link 24 to the arm 7. In this manner, a resilient constraint is provided that has zero rate so that the force generated in the film by the constraint is constant.

FIGURE 7 is a simple illustration of the principle involved and comprises a web 60 fixedly mounted at one end through a spring tension indicator 61 to a frame support 62. A cylindrically shaped hollow tube 63 is carried in a loop of the web 60 with force and movement being applied to the free end of the web 60 as indicated by the double ended arrow 64. Thus, the purposes of this illustration are to show that an up or down movement as indicated by the arrow 64 of the web 60 will cause a rolling of the tube 63, but will not cause any change to the tension indicated on the meter 61. This will be true of the diameter and inertia of the tube 63 is sufficient to eliminate vibrations or disturbance caused at the end of the web 60 upon the movement indicated by the direction of the arrow 64, and if the tube 63 always remains in rolling contact with the web 60.

The tube 63 in FIGURE 7 is made of a relatively large diameter or radius to a small shell thickness so that in essence the radius of gyration of the tube 63 is substantially at the outer surface thereof. It is by making the radius of gyration of the mass about which a web is moving to be substantially coincident with the circumferential surface of the rotating mass which eliminates disturbances at the downstream end of the moving web. In this case, it is desirable to have the torque on the rod or tube resultant from the film tension times the radius of the rod or tube times the mass of the rod or tube be substantially equal and opposite to a torque caused by the mass of the rod or tube times the radius of gyration.

FIGURE 4 illustrates in perspective a vertical cross section of the spool 2 and counterbalancing weight 4 of the apparatus of FIGURES 1 and 2. It is generally contemplated that the spool 2 will be hollow so that in effect, the radius of gyration thereof is substantially on the outer circumferential surface. However, it is obvious that the radius of gyration will not be exactly on the outer circumferential surface, therefore the ring or disc of weight 4 is added at the bottom thereof to in effect move the radius of gyration of the spool 2 outwardly until it substantially conforms with the outer circumferential surface. It is anticipated that the spool 2 will be made from aluminum, which might be solid or hollow, with the weight 4 being made from lead so that this movement of the radius of gyration will be easily accomplished. Although the amount of the weight 4 may be determined mathematically to substantial accuracy, it is normally found that some slight adjustment to the amount of weight will be made after the entire combination is assembled to get the exact relationship with the pivotal arm and the radius of gyration to eliminate all the disturbances at an upstream reference point on the moving web.

FIGURE 5 illustrates a preferred single roller embodiment of the invention where a roller 70 is rotatably mounted about a center 71 and pivotally mounted on an arm 72 about a point 73. A web 74 is passed around the roll 70 to have an uptake tension T1, indicated by numeral 75, being the force necessary to pull the web 74 at a constant speed around the roll 70 substantially perpendicular to the arm 72. A tension T2, indicated by 76, acts as a restraining tension to hold the web 74 tight as it rotates in the direction indicated by the arrow 77 around the roll 70. It should be recognized from this diagram that the web 74 will cover at least 90° of the surface of the roll 70. The mathematical formula relating to the dimensions, angles, and forces in this diagram, which will substantially eliminate any disturbances in the web 74 at an upstream point before the webbing reaches the roller 70 under a constant take-off will be substantially as follows:

$$\frac{M_r - r_2^2 + I_A}{r_2} = I_r \frac{r_2}{r_1^2} \sin(\theta+\beta) \sin(r-\theta)$$

Where I_r=moment of inertia of roller around its axis, I_A=moment of inertia of arm (not including roller) around its pivot, and M_r=mass of roller. Thus, this mathematical relationship between the associated parts in the combination is what is built into the mechanical embodiment of FIGURES 1 and 2. In essence it might be said that the moment of inertia of the roller and the moment of inertia of the arm are so related to the arm and roller radius, the mass of the roller, the angles of incidence and emergence of the film and the normal angle of the arm to cause the movement of the web 74 past a reference point 78 be uniform regardless of downstream disturbances or external disturbances. An appropriate recording or printing means 79 could be positioned at the reference point 78. Naturally, the use of a second roll embodying the principles of the invention on the other

side of the reference point **78** may further enhance the constant movement of the web **74** thereby.

FIGURE 6 illustrates a double roller assembly also providing a uniform movement of a web **80** past a reference point **81** having a recording or printing means **81***a*, and around two rollers **82** and **83** towards a take up at point **84**. In this instance, the rollers **82** and **83** are each rotatably mounted about their centers **85** and **86**, respectively, and pivotally mounted at a common point **87** on a common arm **88**. In this instance, the direction of film or web movement around the rollers **82** and **83** will be as indicated by the arrows **89** and **90**. The angle of the film coming into the roller **82** may be indicated by an angle β while the output angle of the film leaving roller **83** might be indicated by an angle α. In this instance, the length of the pivot arms for rollers **82** and **83** might be varied, as well as the mass of the rollers to make the radius of gyration substantially conform with the outer circumferential surface thereof to properly achieve the objects of the invention. Again, it should be noted that the take off of the film is substantially perpendicular to the pivotal arm **88**. The mathematical formula utilized to achieve the proper interrelation of rollers, pivot arms, and angles of webbing would be as follows:

$$I_{AA}+(M_2l_2)^2+(M_1l_1)^2-[(I_2r_1)^2+(I_1r_2)^2]\frac{l_1l_2}{r_1^2r_2^2}\sin(\beta+\theta)\sin(\alpha+\theta)=O$$

where I_{AA}=inertia of the arm around the pivot **87** (not including rollers).

Thus, it is seen that the objects of the invention have been achieved by providing a roller and associated pivot arm both so controlled that the radius of gyration of the roller and the tension of the pivot thereof will substantially eliminate any downstream disturbances from being transmitted through the film to an upstream position where the film passes a reference point. Photography or other printing applications may be applied to the film at the reference point. Certain mathematical formulas have been developed which show an interrelation of the combination necessary to achieve the torque balance features of the invention. This roller and associated apparatus will insure constant tension and movement of the film past a reference point, despite upstream disturbances necessary with the taking in, or other external forces caused by roll, pitch or yaw in an aircraft.

While in accordance with the patent statutes only one best known embodiment of the invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby, but that the inventive scope is defined in the appended claims.

What is claimed is:

1. In an apparatus for moving a film past a point at a constant uniform speed the combination of

a cylindrically shaped roller,

means rotatably mounting said roller on the longitudinal axis thereof,

a supporting frame,

means pivotally mounting said means rotatably mounting said roller to said frame in substantially parallel relation to allow pivotal movement of said roller,

means to detect the pivotal relation of the roller relative to the frame,

means to resiliently restrain at zero rate the pivotal relation of the roller relative to the frame,

disc means operatively affixed to said roller so as to move the radius of gyration of the roller into substantial coincidence with the circumference defining the roller,

an elongated film strip passed around the roller so that it contacts at least 90° of the circumference thereof and so that one end extends outwardly therefrom substantially perpendicular to the pivotal mounting means, and

means to uniformly pull the film from the one end to effect advancement around the roller and define a uniform movement of the film past a predetermined point before it reaches the roller.

2. An apparatus according to claim **1** where means are provided before the film reaches the roller and before the predetermined point to restrain the movement thereof and effect a tensioning of the film around the roller.

3. An apparatus according to claim **1** where the cylindrically shaped roller is substantially hollow and having a large diameter with a thin wall thickness so the radius of gyration is substantially in coincidence with the circumference defining the roller.

4. In an apparatus for moving a web past a predetermined pont at a constant uniform speed the combination of

a cylindrically shaped roller,

means rotatably mounting said roller on the longitudinal axis thereof in a substantially vertical position,

a supporting frame,

means pivotally mounting said means rotatably mounting said roller to said frame to allow substantially horizontal pivotal movement thereof,

means operatively affixed to said roller so as to move the radius of gyration of the roller into substantial coincidence with the circumference defining the roller,

an elongated web passed around the roller so that it contacts at least 90° of the circumference thereof and so that one end extends outwardly therefrom substantially perpendicular to the pivotal mounting means, and

means to uniformly pull the web from the one end to effect advancement around the roller.

5. In an apparatus for moving a web past a reference point at a constant uniform speed without disturbance the combination of

a roller,

pin means rotatably mounting the roller,

arm means pivotally mounting the arm,

frame means supporting and allowing pivotal movement of the arm means relative thereto, and

a web passed around the roller, said combination being related to each other and a reference plane as follows:

$$\frac{M_r-r_2^2+I_A}{r_2}=I_r\frac{r_2}{r_1^2}\sin(\theta+\beta)\sin(r-\theta)$$

where M_r=mass of the roller; r_2=radius of arm; r_1=radius of roller; I_A=inertia of arm; I_r=inertia of roller; θ=angle from reference plane to arm; β=angle from output web to reference plane; and r=angle from input web to reference plane.

6. An apparatus according to claim **5** which includes means to restrain at the zero rate the movement of the film before it reaches a reference point and the roller to effect a tensioning of the film around the roller and past the reference point.

7. An apparatus according to claim **5** where an annular ring is affixed to the roller which may be adjusted to its weight to thereby adjust the roller mass and moment of inertia to substantially move the radius of gyration into substantial coincidence with the circumferential surface thereof.

8. In an apparatus for moving a web past a reference point at a constant and uniform speed the combination of

a pair of rollers,

pin means rotatably mounting each roller,

arm means operably connected to said pin means to support said pin means in substantially parallel relation,

frame means pivotally mounting said arm means at a point somewhere between said pin means, and a web passed around both rollers, but in opposite sense, said combination being related to each other and to a reference plane as follows:

$$I_{AA}+(M_2l_2)^2+(M_1l_1)^2-(I_2r_1)^2+$$
$$(I_1r_2)^2\frac{l_1l_2}{r_1^2r_2^2}\sin(\beta+\theta)\sin(a+\theta)=O$$

where I_{AA}=the inertia of the arm around its pivot and not including rollers; M_2=mass of one of the rollers; l_2=length of the arm of said one roller to the pivot; M_1=mass of the other roller; l_1=the arm of said other roller to the pivot; I_2=inertia of said one roller about its axis; r_1=radius of said other roller; I_1=inertia of said other roller about its axis; r_2=radius of said one roller; a=angle from the outgoing web to the reference plane; θ=angle from the arm to the reference plane; and

β=the angle from the incoming film to the reference plane.

9. An apparatus according to claim **8** where means are provided to restrain the movement of the film before it reaches a predetermined point in advance of the rollers to effect a tensioning of the film around the rollers and past the recording means.

10. An apparatus according to claim **8** where an annular ring is affixed to each roller which may be adjusted to its weight to thereby adjust each roller mass and moment of inertia to substantially move the radius of gyration into substantial coincidence with the circumferential surface thereof.

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ALLEN N. KNOWLES, *Primary Examiner.*