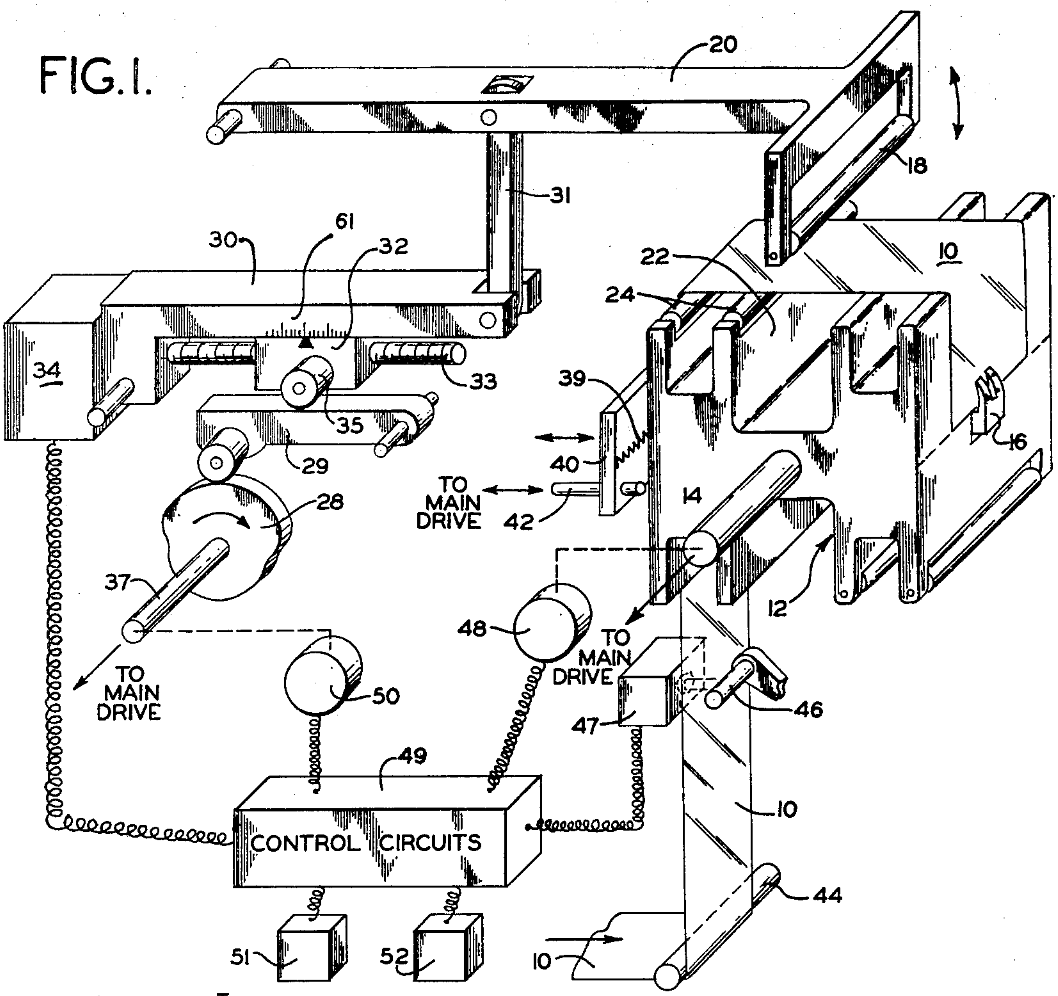
Feb. 10, 1970 W. L. CALVERT ET AL **3,494,526**

ADJUSTABLE DRAW STROKE MACHINE

Filed Sept. 29, 1967 3 Sheets-Sheet 1

FIG. 1.



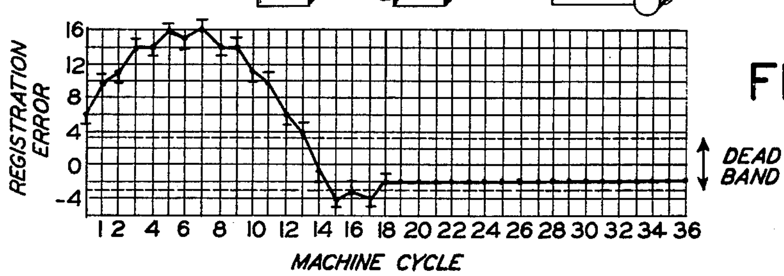


FIG. 3.

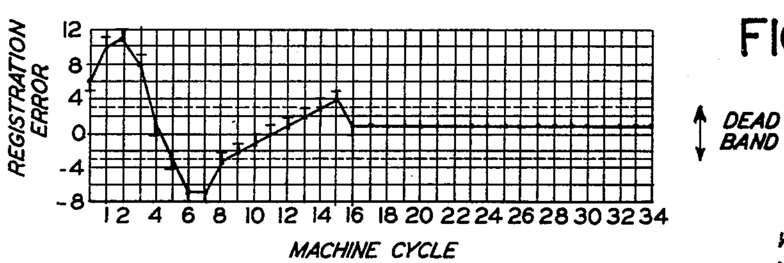


FIG. 4.

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ADJUSTABLE DRAW STROKE MACHINE

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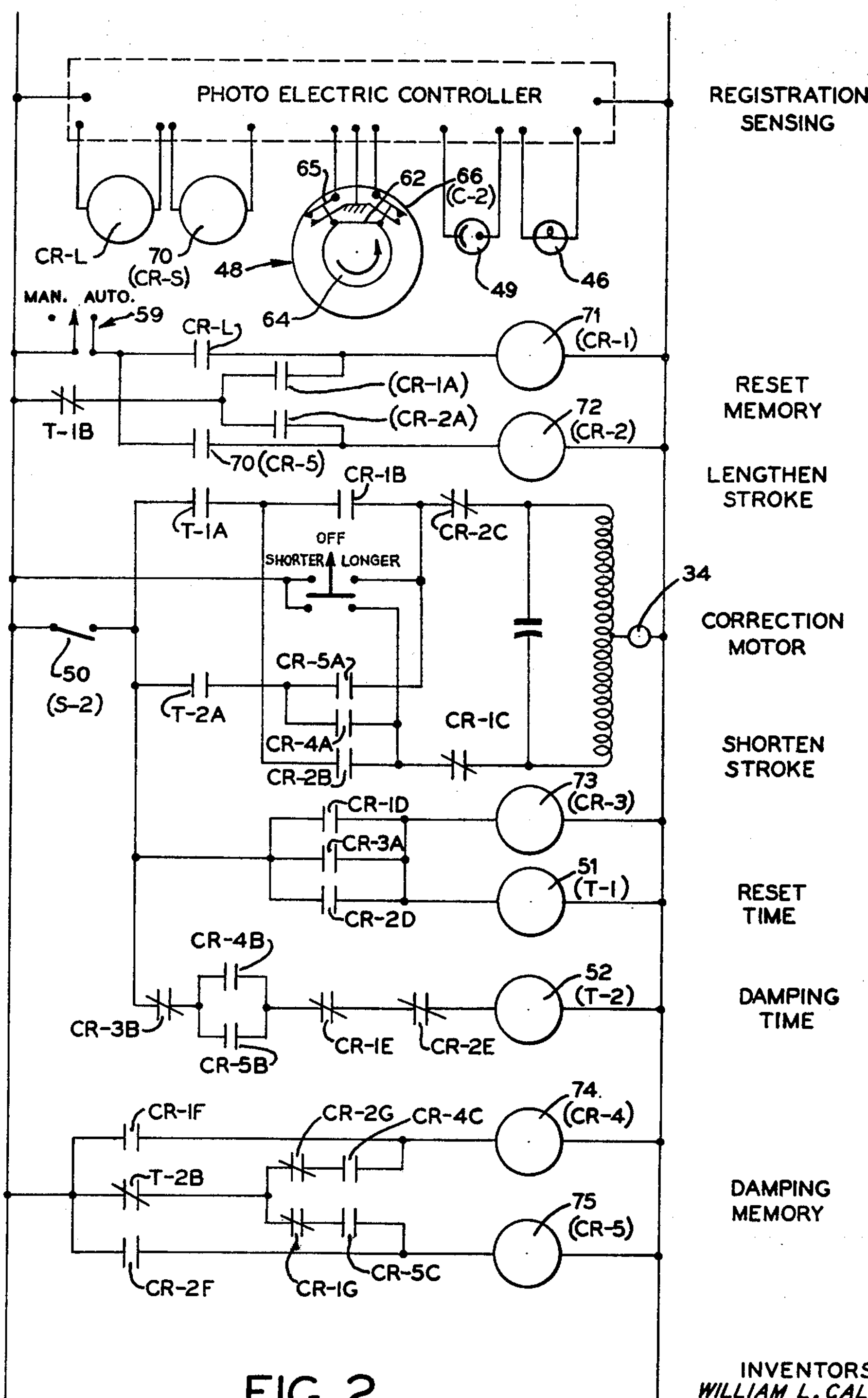

FIG. 2.

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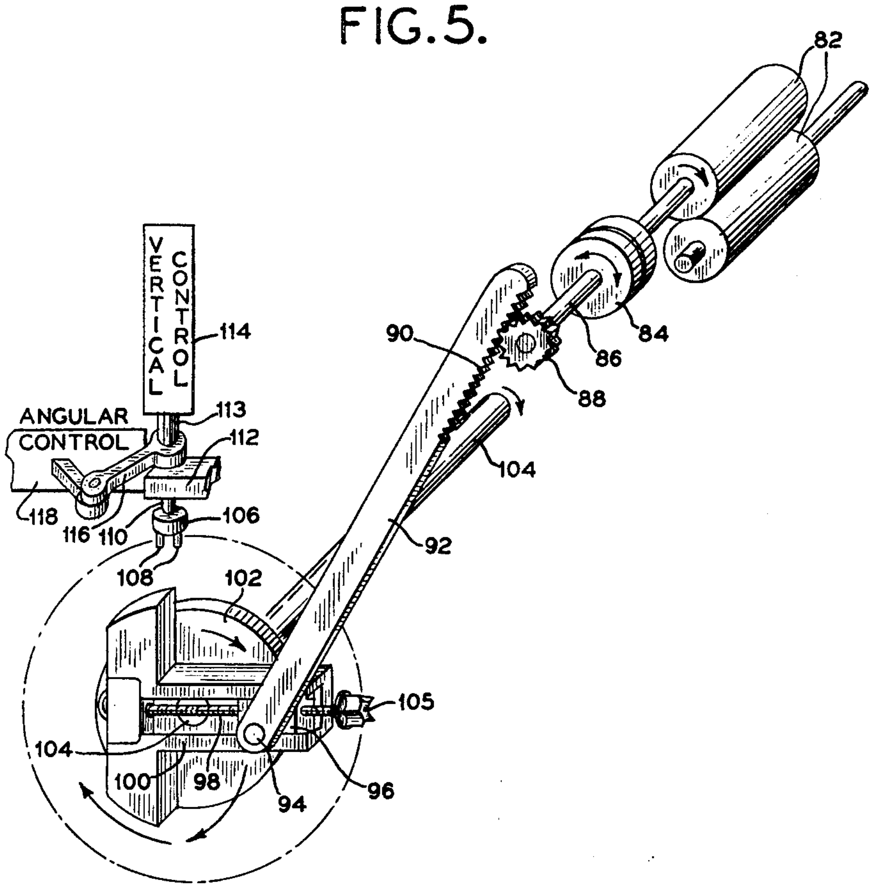
FIG. 5.



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3,494,526
ADJUSTABLE DRAW STROKE MACHINE

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Filed Sept. 29, 1967, Ser. No. 671,749
Int. Cl. B65h 25/10, 25/22
U.S. Cl. 226—32 7 Claims

ABSTRACT OF THE DISCLOSURE

This specification discloses a cam-operated web feed that draws an incremental length with each cycle of the apparatus with smooth acceleration and deceleration. Sensing apparatus, such as a photocell, cooperates with markings on the web to determine whether the web pattern is advanced or retarded with respect to its proper position, and the feed is adjusted automatically by changing the stroke of the feeder in the direction necessary to correct the error. To prevent hunting or instability of the apparatus, each correction made in the stroke in response to the sensing apparatus is partially compensated by a lesser amount by a timer until the stroke is equal to the indicia pattern spacing on the web.

BRIEF DESCRIPTION OF THE INVENTION

This invention relates to an improved device for drawing sequential incremental lengths of material from a long length of material having indicia positioned along the material length to indicate the desired incremental lengths which are to be drawn from said material.

In many applications, it is desirable to draw material from a supply roll in incremental lengths. In a typical example the supply roll could hold a length of tubular film. Incremental lengths are drawn from the roll and cut to provide properly sized blanks for a bag-making machine. In all practical cases, the incremental length needed is determined from indicia applied along the entire length of the material. The indicia must be in such form as to enable use thereof to provide sensing signals. However, the indicia can take many forms, such as labels printed on the stock, perforated lines, opaque length marks, etc. The indicia applied to the stock is used to check the correctness of the incremental length withdrawn.

Although in most production runs, the bag size will be fixed for the run, factors such as film tension will change as the result of change in atmospheric conditions and give rise to the necessity for checking and adjusting the incremental length during the run.

Several equipments are known to the art for the purpose of drawing increments of a continuous web from a storage roll. A large number of these devices employ film transport means which pull the film from the roll until the indicia on the material reaches a sensing device. The transport means is then abruptly braked to stop the transport. The transported length is then the desired length and the incremental length of film may be cut off. However, the abruptness of the drive and braking mechanism introduces undesired sharp peaks of acceleration and deceleration which adversely affect the web tension equipment and introduces sources of both vibration and wear.

In another machine known to the art, the draw stroke is generated by a crank arm. Smooth acceleration is achieved. However, to achieve registration, the draw stroke must be set larger than the maximum incremental length and the web is brought to an abrupt halt in response to a signal from a sensor when the indicia passes the sensor.

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In another form of apparatus, registration control is achieved by providing reference draw strokes equal to the web repeat length. Registration correction is applied by incremental adjustment of the stroke until the web is back in registration when the stroke reverts to its reference length. With such a device, change in web repeat lengths as, for example, that due to shrinkage of the film, requires continuous correction of the draw stroke on each increment. If the web repeat length exceeds the reference length, plus or minus the available incremental correction, the system cannot exercise control and registration is lost.

It is, therefore, an object of the present invention to provide a device for drawing sequential incremental lengths of material from a long length of material having indicia positioned along the material to indicate the desired increments drawn therefrom, and in which means are provided to sense lack of registration, and in which means are provided to change the draw stroke to control the registration.

It is a further object of the present invention to provide an adjustable reference draw stroke which is controlled by sensing means to maintain registration of the drawn length with the predetermined incremental lengths.

It is a further object of this invention to provide a device for drawing incremental lengths of material in which abrupt acceleration and deceleration of the material web is alleviated.

In accordance with these objects, there is provided, in a preferred embodiment of this invention, a device for drawing sequential incremental lengths of material from a long length of material having indicia positioned along entire material length to indicate the incremental lengths desirably drawn therefrom.

The device of this invention consists of sensing means positioned along the web to generate a signal when said indicia is out of registration with said sensing means and to indicate the direction of registration error. The incremental lengths of material are drawn from the web by a draw stroke which draws the material from the roll with approximately harmonic conditions of acceleration and deceleration. If lack of registration is sensed by the sensing means, the signal generated therefrom is processed to correct the stroke of the transport means in such direction as to reduce the error of the next incremental length of material drawn from the roll. Since such adjustment inevitably involves lost motion due to backlash, means are provided to introduce a damping correction to provide the stability of the stroke adjustment thereby to prevent oscillation of the incremental lengths about the desired length.

In this manner, the system provides a floating reference which is not tied to the lengths desired but seeks out the indicia and adjusts the length accordingly.

BRIEF DESCRIPTION OF DRAWINGS

Having briefly described this invention, it will be described in the following portions of the specification, which may be understood by reference to the accompanying drawings, of which:

FIGURE 1 is a perspective view, in diagrammatic form, of a device made in accordance with the present invention;

FIGURE 2 is a schematic diagram of the electric wiring for the apparatus shown in FIGURE 1;

FIGURE 3 is a plot of corrections applied for registration control on sequential cycles of the apparatus shown in FIGURE 1;

FIGURE 4 is a plot, similar to FIGURE 3, but showing a somewhat different control applied to the apparatus; and

FIGURE 5 is a diagrammatic view showing part of a modified construction with which this invention can be used.

DETAILED DESCRIPTION OF THE INVENTION

FIGURE 1 shows apparatus for supplying measured lengths of stock to a bag-making machine. A web of tubular film **10** is fed to the machine from a tension-controlling supply stand (not shown). A turret **12** is rotated about a horizontal axis **14** by means of an indexing drive, and is caused to rotate 180° during each cycle of the apparatus.

The turret **12** is equipped with grippers **16** with which to grip the web of tubular film **10** so that the web will advance into the position shown when the turret **12** rotates. There is a similar gripper **16** on the opposite side of the turret **12**. A festoon roll **18** is mounted on a radius arm **20** by which it is caused to move in and out of an upper cavity **22** of the turret. By penetrating this cavity, the festoon roll **18** causes a further advance of the web **10** over idler rolls **24** carried by the turret **12**.

By controlling the depth of penetration of this festoon roll **18** into the cavity **22**, the total length of film advance is controlled. Movement of the festoon roll **18** is, in fact, caused by a continuously driven cam **28** which transmits motion through a follower arm **29**, a variable fulcrum arm **30** and a link **31** connected to the radius arm **20**. The arm **20** moves about a fulcrum F.

The magnitude of the festoon roll motion is controlled by changing the lateral position of a slide block **32** which can be moved in either direction by a jackscrew **33** driven by a reversible gear head motor **34**.

The character of the motion of the festoon roll **18** is a modified harmonic motion in the apparatus illustrated, and it is dependent to a large extent on the shape of the cam **28**. The magnitude of this motion of the festoon roll **18** is referred to herein as the "stroke" and it is adjusted by changing the position of a follower stud **35** which projects from the block **32** across the top of the follower arm **29**. Motion of the follower arm **29** is transmitted to the block **32** through this follower stud **35**.

The cam **28** is secured to a drive shaft **37** which rotates continuously and which is driven from the main drive of the apparatus. It will be understood that the axle **14** of the turret **12** is also driven from the main drive of the apparatus though through an intermittently operating mechanism which rotates the axle **14** one-half revolution per each cycle of the apparatus, as previously explained. By having these parts driven from the same main drive, the cam can be maintained in synchronism with the turret **12** so that the motion of the festoon roll **18** occurs only when the turret **12** is stopped and the cavity **22** is located under the festoon roll **18**.

A knife **39** attached to a frame **40** is advanced toward the turret **12** after each downward movement of the festoon roll **18** and this knife **39** cuts the web **10** so that a length of web, which is intended to be the correct length for a bag blank, extends from the gripper **16** to the knife **39**. The operation of the knife **39** and the frame **40** by which the knife is carried, is effected by push rods **42** which are also operated from the main drive of the apparatus through timing mechanism, the illustration of which is not necessary for a complete understanding of this invention.

As the knife **39** retreats from the turret **12**, the gripper on that side of the turret, which is similar to the gripper **16**, but turned in the opposite direction, that is, downward when the turret is in the position shown in FIGURE 1, grips the web **10** preparatory to pulling a new length of web around a guide roll **44** on the next half revolution of the turret **12**. As the gripper on the left side of the turret **16** moves into contact with the web **10**, the gripper **16** on the right hand side of the turret releases the bag blank **10'** which is draped over the top of the turret and the bag blank is moved from the turret to the bag-making machine by feed means on the bag-making machine. This sequence of operation is repeated once during each cycle of the bag-making machine.

Registration of the metered length of tubular film web **10** with a printed pattern on the web is achieved in the following manner. A web scanning system comprising a light source **46** and a photosensitive cell **47** scans the web **10** as the turret **12** rotates. This photocell **47** may be positioned to receive either reflected or transmitted light. In the illustrated construction it receives transmitted light. The scanning system creates an electrical pulse when a color boundary passes the scanning point, in conjunction with a registration reference switch **48** which is mechanically coupled with the turret **12**. This determines whether the previous pattern on the web is advanced, retarded, or within acceptable limits with respect to the desired position; and sets up control circuits in a controller **49** to drive the jack screw motor **34** in the proper direction to correct the error.

The energizing of the motor **34**, however, is delayed until the festoon roll **18** is once again in its upper position; this condition being revealed to the control circuits by means of a selector or cycle reference switch **50** which is mechanically coupled to the drive shaft **37** that rotates the cam **28**. A timer **51** determines the length of time that the stroke adjusting motor **34** will run and, therefore, determines the magnitude of the stroke correction increment. In the preferred mode of operation, a stroke adjustment is followed, during the next machine cycle, by a reverse correction of lesser magnitude. A second timer **52** determines the extent of this reverse correction. An explanation of the manner in which this mode of operation damps out oscillations and maintains stability of the registration system will be explained in connection with FIGURES 3 and 4.

FIGURE 2 shows the control circuit for the preferred form of the invention. In order to initially set the system within registration control limits, selector switch **59** is set in its manual position in which it opens its circuit. This prevents the photoelectric controls from operating the stroke adjusting motor **34**. The desired metered length of film is set by driving the motor **34**, by means of a selector switch **50** until the slide block **32** (FIGURE 1) is in its proper position for the desired length of web. The metered length is indicated by a position sensor **61** on the slide block arm **30**.

The web **10** is then manually cut at the proper position with respect to its printing, and the web is locked on the right side of the turret **12** with the gripper on that side of the turret. The turret is rotated 90° and the photoelectric scanner head consisting of the light source **46** and the photocell **47** is positioned so that the light beam is projected on the web interface at the reference point which is to exert the control.

A flat section **62** (FIGURE 2) on a cam **64** is set between contacts **65** (C–1) and another contact **66** (C–2). The reference switch **48** includes the cam **64** and the contacts **65** and **66**. The cam **64** of this reference switch **48** makes one revolution for each revolution of the turret **12**; that is, one revolution for two cycles of the apparatus.

With the operations thus far described, there reference web indicia on the web **10** is in register with the control apparatus. The selector switch **59** is then set to its automatic position. The position of the flat **62** on the cam **64** of the reference switch **48** at the time when the web reference point passes the sensing end, that is the light source **46** and photocell **47**, determines the corrective action to be taken, if any.

When the flat **62** of the reference switch **48** passes the follower of the contacts **65** or **66**, these contacts close. Corrective action takes place if the web reference point passes the photoelectric sensing head when either one of the contacts **65** or **66** is closed. Since the reference switch cam **64** makes one revolution as the turret makes one revolution, the web registration is sensed every other cycle.

The control action of the circuitry is as follows:

As long as the web **10** is within registration limits (as determined by the angular separation of the followers of the contacts **65** and **66** of reference switch **48**), the sensing head "sees" the web reference point when the cam flat **62** is between the contacts **65** and **66**, and no control action takes place. The control system remains passive as long as this condition exists.

If the web reference point advances beyond the allowable limits, the sensing head "sees" it when the contact **66** is closed. The photoelectric controller responds to this condition by momentarily energizing a relay **70** (CR–S). The normally open contact of relay **70** (CR–S) closes momentarily energizing the coil of another relay **72** (CR–2). The contact of relay **72** (CR–2) operates on the circuit as follows:

CR–2A closes, and through closed contact (T–1B) of timer **57** (T–1), locks in the coil of relay **72** (CR–2).
CR–2B closes in the "shorten stroke" leg of the correction motor **34** circuit, preparing it for operation.
CR–2C opens in the "lengthen stroke" leg of the stroke correction motor **34** circuit locking it out.
CR–2D closes, preparing a relay **73** (CR–3) and reset timer **57** (T–1) for operation.
CR–2E opens, locking out the damping timer **52** (T–2).
CR–2F closes, energizing another relay coil **75** (CR–5).
CR–2G opens, locking out a relay **74** (CR–4).

The contacts of relay **75** (CR–5) operate on the circuit as follows:

CR–5A closes, preparing the "lengthen stroke" circuit for operation.
CR–5B closes, preparing damping timer **52** (T–2) for operation.
CR–5C closes and through contacts CR–1G of relay **71** (CR–1), and contacts T–2B of timer **52** (T–2) locks in the coil of relay **75** (CR–5).

The circuit is now prepared to correct the registration error by resetting the slide block **32** (FIGURE 1) to shorten the festoon roll stroke. This in effect delays the web reference point passing by the sensing head. This action is in the direction of bringing the web reference point passing the sensing head, back into time phase with the reference switch **48**.

When the festoon roll **18** retracts to its full up postion, the cycle reference switch **50** (S–2) (FIGURE 2) closes. The following sequence of electrical action then takes place.

Relay coil **73** (CR–3) energizes through contact CR–2D.

CR–3A closes, locking in relay **73** (CR–3).

CR–3B opens, locking out timer **52** (T–2).

Reset timer **51** (T–1) starts its timing cycle by closing contact T–1A.

The slide block adjusting motor **34** is energized through the closed contacts T–1A, CR–2B, and CR–1C, to shorten the stroke of the festoon roller.

When reset timer **51** (T–1) times out:

T–1A opens, deenergizing the slide block drive motor **34**,

T–1B opens, deenergizing the relay coil **72** (CR–2).

All of the contacts of relay **72** (CR–2) revert to their normal condition without changing the state of any circuit.

The next action of the circuit is that cycle reference switch **50** (S–2) opens. This deenergizes relay **73'** (CR–3) and resets the reset timer **51** (T–1).

The contacts of relay **73** (CR–3) revert to their normal conditions without changing the state of any circuit.

The contacts of reset timer **51** (T–1) revert to their initial conditions without changing the state of any circuit.

At this point the operation has gone through one complete cycle. The registration control circuits go back to

their initial conditions with the exception of relay **75** (CR–5) which is energized and held in through closed contacts T–2B, CR–1G and CR–5C, and the registration reference switch **48** which has only completed one-half revolution.

The next machine cycle cannot produce a correction signal from the web reference point, because the registration reference switch **48** is 180° out of phase with the photoelectric sensor.

The control circuit maintains its condition until the cycle reference switch **50** (S–2) closes.

At this point damping timer **52** (T–2) is energized through closed contact CR–3B, CR–5B, CR–1E, and CR–2E.

As timer **52** (T–2) starts timing, its contact (T–2A) and through closed contacts CR–5A and CR–2A energizes the slide block adjusting motor **34** to lengthen the stroke of the festoon roller.

When the damping timer **52** (T–2) times out:

T–2A opens, denenergizing the slide block adjusting motor **34**.

T–2B opens, denenergizing the relay **75** (CR–5).

When relay **75** (CR–5) deenergizes:

CR–5B opens, resetting the damping timer **52** (P–2).

CR–5A ad CR–5C revert to their normal conditions without changing the state of any circuit.

When cycle reference switch **50** (S–2) opens, the registration circuit is back to its initial condition ready to make another registration check.

The basic stability of this type of control system is dependent upon the relative values of the systems' parameters. The main parameters are:

Dead band, backlash, reset correction, damping correction, and initial registration condition. To maintain control the damping correction must be equal to or greater than one-half the backlash, and the reset correction must be greater than the damping correction.

To illustrate the ability of the system to control under these conditions, the control action will be illustrated. For purposes of simplicity and generality the parameter values will be expressed in units of length and will be relative rather than absolute. In this example, damping correction follows every reset correction. The system inherent parameter is:

Backlash equal to one unit (initially in the direction to deter the reset action).

The assigned system parameters are dead band, which is equal to a group of six units.

Reset correction which is four units.

Damping correction which is three units.

The initial condition parameters are:

Registration error—six units too far advanced (reference to the center of the dead band).

Machine stroke error—four units too long (reference to initial web repeat length).

The sequence of operations is illustrated in FIGURE 3 and is as follows:

Initial conditions

Web 6 units advanced of dead band center.

Machine stroke error 4 units too long.

Backlash 1 unit, position will deter a reset correction.

Machine cycle 1

Registration check is made and found out of limits.

The web position is now 10 units too far advanced because of the present 4 unit excessive machine stroke.

The 4 unit corrective action of the reset timer overcomes the one unit of backlash and decreases the stroke error from 4 to 1 unit too long.

Machine cycle 2

The web position is now 11 units too far advanced because of the last 1 unit excessive machine stroke.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and increases the stroke error from 1 to 3 units too long.

Machine cycle 3

Registration check is made and found out of limits.

The web position is now 14 units too far advanced because of the last 3 unit excessive machine stroke.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and decreases the stroke error from 3 units too long to the correct stroke length.

Machine cycle 4

The web position remains 14 units too far advanced, since the last stroke was equal to the web repeat length.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and increases the stroke to 2 units too long.

Machine cycle 5

Registration check is made and found out of limits.

The web position is now 16 units too far advanced because of the last 2 unit excessive machine stroke.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and changes the stroke error from 2 units too long to 1 unit too short.

Machine cycle 6

The web position is now 15 units too far advanced because the last stroke length was 1 unit too short.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke error from 1 unit too short to 1 unit too long.

Machine cycle 7

Registration check is made and found out of limits.

The web position is now 16 units too far advanced because of the last 1 unit excessive machine stroke.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and changes the stroke error from 1 unit too long to 2 units too short.

Machine cycle 8

The web position is now 14 units too far advanced because the last stroke was 2 units too short.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke from 2 units too short to the correct stroke length.

Machine cycle 9

Registration check is made and found out of limits.

The web position remains 14 units too far advanced since the last stroke was equal to the web repeat length.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and decreases the stroke length to 3 units too short.

Machine cycle 10

The web position is now 11 units too far advanced because the last stroke was 3 units too short.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke error from 3 to 1 unit too short.

Machine cycle 11

Registration check is made and found out of limits.

The web position is now 10 units too far advanced because the last stroke was 1 unit too short.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and decreases the stroke length from 1 unit to 4 units too short.

Machine cycle 12

The web position is now 6 units too far advanced because the last stroke was 4 units too short.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke error from 4 units too short to 2 units too short.

Machine cycle 13

Registration check is made and found out of limits.

The web position is now 4 units too far advanced because the last stroke was 2 units too short.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and decreases the stroke length from 3 to 5 units too short.

Machine cycle 14

The web position is now 1 unit too far retarded (but within the dead band) because the last stroke was 5 units too short.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke error from 5 to 3 units too short.

Machine cycle 15

Registration check is made and found to be out of limits.

The web position is now 4 units too far retarded because the last stroke was 3 units too short.

The 4 unit corrective action of the reset time now works to lengthen the stroke because the web is lagging in registration. The corrective action does not have to overcome backlash because it is correcting in the same direction as the last (damping) correction. This reset action changes the stroke error 3 units too short to 1 unit too long.

Machine cycle 16

The web position is now 3 units retarded (but within the dead band) because the last stroke was 1 unit too long.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke length from1 unit too long to 1 unit too short.

Machine cycle 17

Registration check is made and found to be out of limits.

The web position is now 4 units retarded because the last stroke with 1 unit too short.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and changes the stroke length from 1 unit too short to 2 units too long.

Machine cycle 18

The web position is now 2 units lagging (but within the dead band) because the last stroke was 2 units too long.

The 3 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke length from 2 units too long to the web repeat length.

Machine cycle 19

Registration check is made and found to be within limits.

The web position is still 2 units retarded (but within the dead band) because the last stroke was equal to the web repeat length.

No corrective action is taken by the reset timer.

Machine cycle 20

The web position is still 2 units retarded (but within the dead band) because the last stroke was equal to the web repeat length.

No corrective action is taken by the damping timer.

The web will stay in registration and no control action will take place until, due to changes in repeat length (stretch or shrinkage), reproducibility of machine stroke, or other external influences, the web is caused to drift or suddenly move out of register. The control system will then repeat the type of process illustrated in the preceding registration action sequence.

The invention can be modified in various ways. The method of this invention consists essentially of three-position control (i.e. a "dead band" provided within which no corrective action is called for) applied, not to the position of the web, but to the transport stroke, with special circuit features which suppress the natural tendency of such systems to be unstable. This control system, when applied to any web of transport mechanism (draw rolls, draw fingers, turret, etc.) should be considered within the scope of this invention. Conversely the film metering and cut-off mechanism described herein should, likewise be considered within the scope of the invention.

Various changes can be made in the mechanism. For example the web may be held on the turret by suction cups rather than mechanical grippers; and if preforated web is used, the photosensing device may be replaced with a pneumatic sensing device. The turret lends itself to a variety of configurations; the festoon roll may be supported and actuated by a variety of systems other than the mechanism illustrated, and the positioning of the variable fulcrum may be accomplished by mechanical, hydraulic, or pneumatic means other than the jack screw illustrated. The timers may be replaced by counters where such are more compatible with the adjustment of the fulcrum or follower stud adjusting means.

FIGURE 5 shows another type of apparatus with which the control mechanism of this invention can be used. The apparatus shown in FIGURE 5 has draw rolls **82** for advancing a web. The draw rolls are driven through a clutch brake unit **84** which is electrically operated and can be used at any time to disengage the draw rolls from the power supply and to stop them quickly with a brake. Power is supplied to the draw rolls **82** through the clutch **84** by a drive shaft **86** which is driven by a pinion **88**. This pinion is operated by a rack **90** on a reciprocating element **92** pivotally connected by an axle **94** to slide block **96** on a jack shaft **98**.

The slide block **96** and jack shaft **98** are part of a variable radius crank assembly which includes also a frame **100** attached to a wheel **102** on a shaft **104** that is driven from the main power supply of the apparatus.

The stroke of the element **92** and of the rack **90** depends upon the distance of the slide block **96** from the center of rotation of the wheel **102**. This distance can be varied by turning the jack shaft **98** one way or the other. A shorter stroke causes the pinion **88** to turn the clutch **84** and the rolls **82** for a shorter distance in the direction of feed; and conversely an increase in the length of the stroke of the element **92** and rack **90** increases the amount of feed of the web by the draw rolls **82** for each rotation of the wheel **102**.

In order to rotate the jack screw **98** while the wheel **102** is rotating, there is a star wheel **105** attached to the end of the jack screw **98** which projects beyond the wheel **102**. A dog **106** is located in a position adjacent to the orbit of the star wheel **104**. This dog **106** has two studs **108** extending downward and the dog **106** is attached to the lower end of a shaft **110** which is movable up and down in a bearing **112** by a plunger **113** of a vertical controller **114**. A crank **116** is used to rotate the shaft **110** through a limited angular movement, and the crank **116** is actuated by an angular control **118**.

When the shaft **110** is in raised position, the dog **106** and the studs **108** are outside of the orbit of the star wheel **104** and no adjustment of the jack screw takes place. When the shaft **110** is moved downward, it brings the studs **108** into position where one or the other of them is in the path of the star wheel **104** depending upon the angular position of the crank **116**. If the star wheel is to be turned towards the right, then the stud **108** which will contact with the star wheel to turn it in that direction is placed in position to touch and turn the star wheel each time the star wheel passes the dog **106**. If the jack screw **98** is to be turned in the other direction, then the crank **116** is moved angularly to rotate the shaft **110** to bring the stud **108** on the other side of the star wheel into contact with the star wheel on each revolution so that the star wheel turns in the opposite direction.

In applying this invention to the apparatus shown in FIGURE 5, the detection of an error is used to operate the vertical control **114** to lower the shaft **110** so that the studs **108** are close enough to the axis of rotation of the wheel **102** to be placed in the path of the star wheel **104**. The control signals which determine whether the error is in advance or a retard error are then used to operate the angular control **118** to rotate the shaft **110** so that the stud **108** which contacts with the star wheel will be on the side to cause a correction to counteract the registration error.

With the apparatus of FIGURE 5 operated by the control mechanism of this invention, counters can be used in place of the timers described in connection with FIGURE 2. It is advantageous to use counters so that when the system senses the need to retard or advance the web, one counter determines the number of machine cycles during which one of the dog studs **108** engages the jack screw to correct the stroke, and the other counter determines the number of reverse correction increments subsequently applied to prevent oscillation of the system. Such an application of the control system eliminates the need for operating the clutch brake **84** in connection with corrections in the registration and thus permits the machine to operate with a smooth, complete harmonic draw stroke and with no abrupt cut-off. These advantages are particularly significant for a high speed machine where inertia forces are objectionable when using a clutch brake unit for correcting registration.

If the apparatus of this invention is constructed so as to allow the making of the stroke correction immediately following the registration check, then the reset memory section of the control system can be eliminated. The invention is not limited to the circuitry explained in the preferred form of the system shown in FIGURE 2 and the basic control action can be performed in a countless variety of ways such as counters, hydraulic actuators, fluidics, etc.

The mode of operation is also not limited to the preferred form illustrated in FIGURE 3. For example the damping correction can be performed at various times during the control action. One example is that the registration check can be made every cycle, instead of every other cycle as already described. When the web registration is out of limits, the reset correction is made and the damping correction can be made only on the first cycle that the web comes into the dead band. To maintain control in this mode of operation, in general the damping correction should be greater than the backlash and the reset correction should be greater than the damping correction minus the backlash.

To illustrate the ability of the system to control in this mode of operation, the action is illustrated in FIGURE 4. As in the example given in FIGURE 3, the parameter values will be expressed in units of length and will be relative rather than absolute. For example:

Backlash—1 unit (initially in the direction to deter reset action)
Dead band—6 units wide
Reset correction—4 units
Damping correction—4 units
Registration error—6 units too far advanced (referenced to center of dead band)
Machine stroke error—4 units too long (referenced to initial web repeat length)

Machine cycle 1

Registration check is made every cycle.
Web is found out of limits.
The web position is now 10 units too far advanced because of the present 4 unit excessive machine stroke.

The 4 unit corrective action of the reset timer overcomes the 1 unit of backlash and decreases the stroke error from 4 to 1 unit to long.

Machine cycle 2

Web found out of limits.

The web position is now 11 units too far advanced because of the last 1 unit excessive machine stroke.

The 4 unit corrective action of the reset timer changes the stroke from 1 unit too long to 3 units too short.

Machine cycle 3

Web is found out of limits.

The web position is now 8 units too far advanced because the last stroke was 3 units too short.

The 4 unit corrective action of the reset timer changes the stroke from 3 to 7 units too short.

Machine cycle 4

The web is found within limits.

The position is now 1 unit too far advanced (but within the dead band) because the last stroke was 7 units too short.

The 4 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke from 7 units too short to 4 units too short.

Machine cycle 5

The web is found within limits.

The web position is now 3 units too far retarded (but just in the dead band) because the last stroke was 4 units too short.

No corrective action takes place.

Machine cycle 6

The web is found out of limits.

The web position is now 7 units too far retarded because the last stroke was 4 units too short.

The 4 unit corrective action of the reset timer changes the stroke from 4 units too short to the web repeat length.

Machine cycle 7

The web is found out of limits.

The web position is still 7 units too far retarded because the last stroke was equal to the web repeat length.

The 4 unit corrective action of the reset timer changes the stroke from the web repeat length to 4 units too long.

Machine cycle 8

The web is found within limits.

The web position is now 3 units too far retarded (but just within the dead band) because the last stroke was 4 units too long.

The 4 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke length from 4 units too long to 1 unit too long.

Machine cycle 9

The web is found within limits.

The web position is now 2 units too far retarded (but within the dead band) because the last stroke was 1 unit too long.

No corrective action takes place.

Machine cycle 10

The web is found within limits.

The web position is now 1 unit too far retarded (but within the dead band) because the last stroke was 1 unit too long.

No corrective action takes place.

Machine cycle 11

The web is found within limits.

The web position is now right in the center of the dead band because the last stroke was 1 unit too long.

No corrective action takes place.

Machine cycle 12

The web is found within limits.

The web position is now 1 unit too far advanced (but still within the dead band) because the last stroke was 1 unit too long.

No corrective action takes place.

Machine cycle 13

The web is found within limits.

The web position is now 2 units too far advanced (but still within the dead band) because the last stroke was 1 unit too long.

No corrective action takes place.

Machine cycle 14

The web is found within limits.

The web position is now 3 units too far advanced (but just within the dead band) because the last stroke was 1 unit too long.

No corrective action takes place.

Machine cycle 15

The web is found out of limits.

The web position is now 4 units too far advanced because the last stroke was 1 unit too long.

The 4 unit corrective action of the reset timer changes the stroke length from 1 unit too long to 3 units too short.

Machine cycle 16

The web is found within limits.

The web position is now 1 unit too far advanced (but within the dead band) because the last stroke was 3 units too short.

The 4 unit corrective action of the damping timer overcomes the 1 unit of backlash and changes the stroke length from 3 units too short to the repeat length of the web.

The preferred embodiment of the invention has been illustrated and described and some modifications have been suggested, but other changes and modifications can be made and various features can be used in different combinations.

What is claimed is:

1. A device for drawing sequential incremental lengths from a long length of material having indicia positioned along the material length to indicate the incremental lengths desirably drawn therefrom, comprising:

(a) transport stroke means for advancing an end portion of predetermined length of said material, said predetermined length being related to the amplitude of the stroke of said transport stroke means;

(b) sensing means positioned between said transport stroke means and said long length of material for determining whether the indicia is in register with said sensing means;

(c) apparatus operated in timed relation with the transport stroke means for actuating the sensing means at the end of the stroke of said transport stroke means;

(d) means responsive to said sensing means for adjusting the transport stroke means to apply a reset correction to said stroke when the sensing means indicate lack of registration with said indicia to change the length of the stroke to bring a subsequent indicia into registration with said sensing means; and

(e) means for applying a damping correction to the adjustment of the stroke of said transport stroke means in a direction opposite to that of the reset correction.

2. A device in accordance with claim **1** characterized by mechanism for operating said means for an applied damping correction after each reset correction.

3. A device in accordance with claim **1** characterized by mechanism for operating said means for applying a damping correction on the first cycle in which no reset correction is applied following a cycle in which a reset correction has been made.

4. A device in accordance with claim **1** characterized by the means for adjusting the stroke of said transport stroke means having a backlash lost motion, and characterized by the reset correction being greater than the damping correction, and the damping correction being equal to or greater than one-half the backlash lost motion.

5. A device for drawing sequential incremental lengths from a long length of material having indicia positioned along the material length to indicate the incremental lengths desirably drawn therefrom, comprising:

(a) transport stroke means for advancing an end portion of predetermined length of said material, said predetermined length being related to the amplitude of the stroke of said transport stroke means, said transport stroke means including operating mechanism that has rotating means which produce a modified harmonic motion of the part of the transport stroke means that contacts with the material which is advanced by said transport stroke means, said rotating means including a cam, and motion transmitting connections operated by the cam to move through its stroke the part of the transport stroke means that contacts with the material;

(b) sensing means positioned between said transport stroke means and said long length of material for determining whether the indicia is in register with said sensing means;

(c) apparatus operated in timed relations with the transport stroke means for actuating the sensing means at the end of the stroke of said transport stroke means; and

(d) means responsive to said sensing means for adjusting the transport stroke means to apply a reset correction to said stroke when the sensing means indicate lack of registration with said indicia to change the length of the stroke to bring a subsequent indicia into registration with said sensing means.

6. A device in accordance with claim **5** and characterized by the motion transmitting connections including a lever moved angularly by the cam, and adjustable means movable to change the effective length of the lever and the resulting displacement transmitted by said lever to the part of the transport stroke means that contacts with the material.

7. A device in accordance with claim **6** characterized by the means responsive to the sensing means including controllers that produce a damping adjustment of the transport stroke means in a direction opposite to the reset correction and of less magnitude than the reset correction.

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