May 1, 1956 H. L. McWHORTER 2,743,881

WEB TENSION CONTROL

Filed Feb. 9, 1953 2 Sheets-Sheet 1

Fig. 1

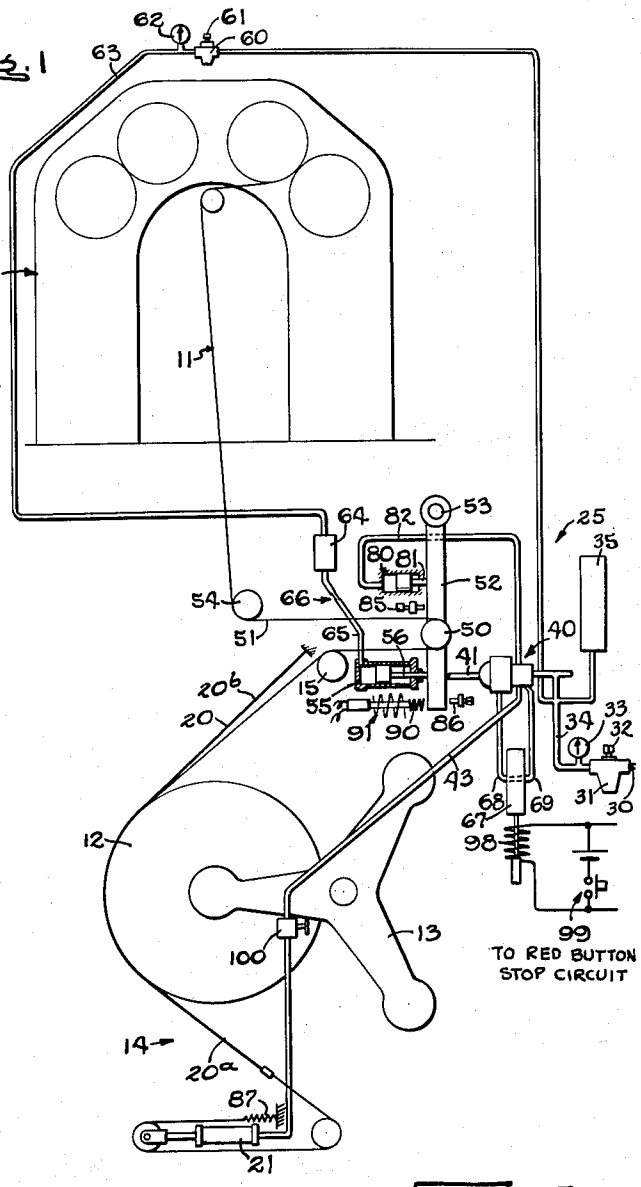


Fig. 4

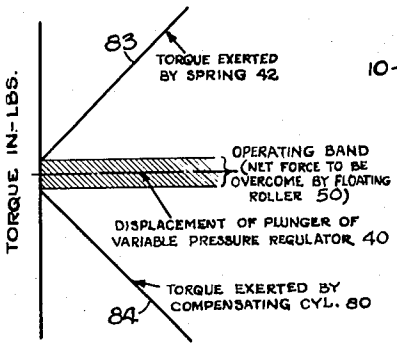
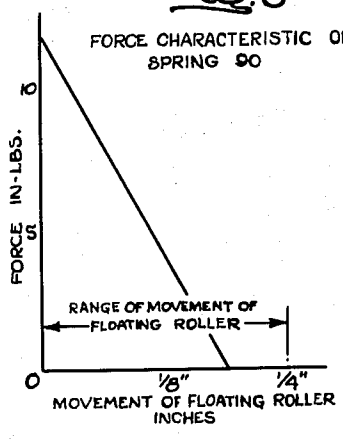


Fig. 5



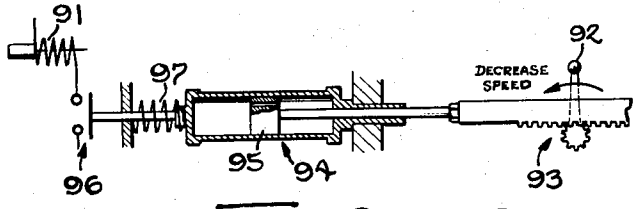
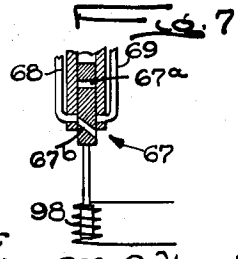


Fig. 6

Fig. 7



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Fig. 2

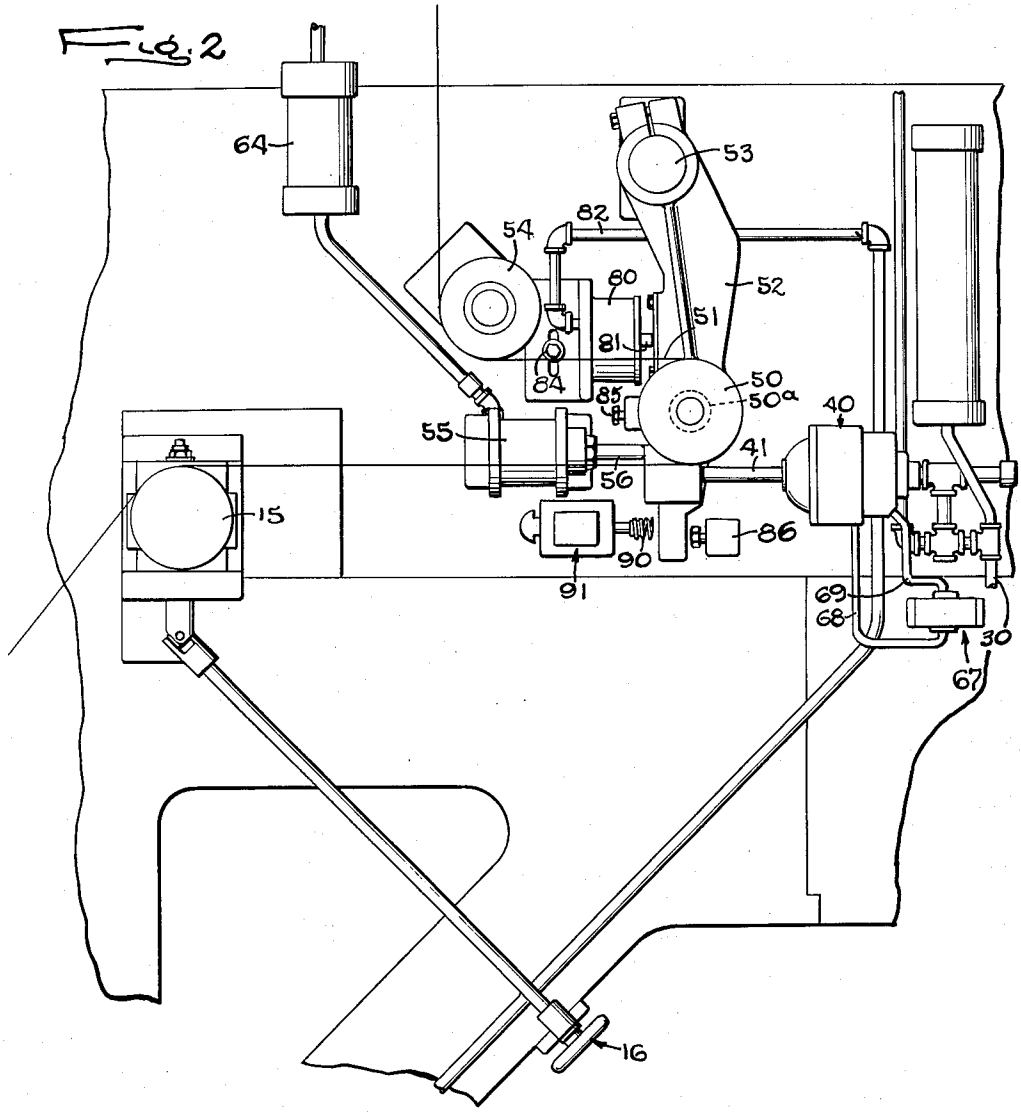
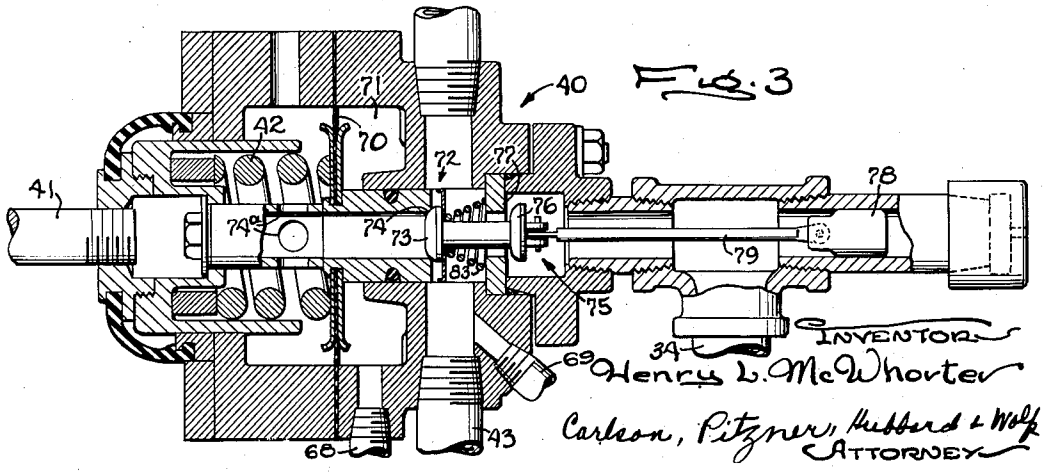


Fig. 3



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United States Patent Office 2,743,881 Patented May 1, 1956

2,743,881

WEB TENSION CONTROL

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Application February 9, 1953, Serial No. 335,762

22 Claims. (Cl. 242—75)

The present invention relates to web tension control systems of the type finding particular utility in web-fed printing presses.

Web breakage, which is both costly and hazardous in a high speed printing press, has been blamed almost universally on defects in the web. It has been my observation, however, that web breakage is traceable in most instances to the inability of conventional tension control arrangements to handle transient disturbances caused, for example, by rolls which are out-of-round because of mishandling during shipment or the like. To improve the situation, steps have been taken to increase the sensitivity of the conventional systems. Simply increasing sensitivity usually causes a tendency to overcontrol, making it necessary to resort to excessive use of shock absorbers, thereby sacrificing speed of response. More elaborate systems have been suggested employing derivative action; however, such systems are not only expensive but require more frequent adjustment and maintenance.

It is an object of the present invention to provide a tension control system which is simple and inexpensive, but which nevertheless enables control of tension under all conditions encountered in the operation of modern presses, substantially reducing web breakage. It is another object to provide a tension control system which is capable of overcoming transient disturbances and particularly those disturbances caused by out-of-round paper rolls. It is another object of the invention to provide a tension control system which is capable of correcting disturbances having a wide range of frequency and which is fully effective for both large and small diameter paper rolls.

It is another object to provide a web tension control which avoids any transient loss of tension during slowdown and which prevents momentary overrun of the roll when the press motor controller is moved in the "decrease speed" direction.

It is an object of the invention to provide a control arrangement which overcomes the problem of belt slap.

It is a further object of the invention to provide a tension control system which is easily set or adjusted by the press operator directly in terms of web tension.

It is still another object of the invention to provide a control system which is sensitive and which requires only a small amount of energy to produce a corrective change.

It is an object to provide a control system which eliminates waste of pressure fluid and which has extremely low power requirements under normal running conditions.

Other objects and advantages will be apparent upon reading the attached detailed description and upon reference to the drawings, in which

Figure 1 is a schematic diagram of the present control system as applied to a conventional printing press.

Fig. 2 is an external view of the major control components used in the system of Fig. 1.

Fig. 3 shows a cross section of the variable pressure regulator employed in practicing the present invention.

Fig. 4 shows the net force characteristic of the variable pressure regulator.

Fig. 5 shows the force characteristic of the deceleration spring.

Fig. 6 shows the means for energizing the deceleration solenoid.

Fig. 7 shows diagrammatically the position of the emergency valve when making a red button stop.

While the invention will be described herein in connection with a preferred embodiment, it will be understood that I do not intend to limit the invention thereto, but intend to cover all alternative constructions and uses falling within the spirit and scope of the appended claims.

Turning now to Figs. 1 and 2, a control system constructed in accordance with the present invention is shown installed on a conventional printing press. The printing press is indicated at **10**, and has the usual arrangement of printing and impression cylinders. A web **11** is fed from a roll **12**, which is mounted on a spider **13** in a web supply mechanism **14** located below the press floor. For the sake of simplicity conventional mechanisms for bringing the roll up to speed and for effecting a splice or paster have been omitted from the drawing. The web, after leaving the roll **12**, passes over a conventional cocking roller **15** having an adjustment **16**.

In order to produce tension in the web **11**, a brake is provided having a belt **20** and brake cylinder or actuator **21**. Only one belt and one brake cylinder have been shown. It will be understood that in a normal installation a plurality of belts are used, each connected to a brake cylinder, the cylinders being connected in parallel to the source of pressure fluid.

In practicing the present invention, improved means are provided for detecting a departure in the desired value of web tension and for causing pressure fluid to be supplied to the brake cylinder in accordance with such departure to effect a corrective change in braking force. The control mechanism for accomplishing this is indicated generally at **25**, the physical appearance being set forth in some detail in Fig. 2. To simplify understanding, primary reference may be made to Fig. 1, which is a schematic representation of the various parts used in the system. Air is supplied from a compressed air source through a line **30**. The pressure is adjusted by means of a constant pressure regulator **31** having an adjustment **32** and an indicator dial **33**. Such regulator is of conventional design, holding the set pressure in spite of variations in the supply line.

The function of the regulator **31** under emergency or red button stop conditions will be discussed at a later point. From the regulator the air is fed into a line **34** and is stored in a reservoir **35**.

In order to control the pressure of the air flowing to the brake cylinder **21** under normal operating conditions, a variable pressure regulator **40** is used having a control rod **41**. The regulator is of the type having an internal control spring **42** and is so constructed that the pressure appearing at an output line **43** is determined by the position of the control rod **41** and the degree of compression of the spring **42** associated therewith.

Arranged in the path of movement of the regulator control rod is a floating roller **50** which engages a loop of web indicated at **51**. The floating roller **50** is mounted for movement in a direction to lengthen and shorten the loop of web. In carrying out the invention the floating roller is suspended by a pair of pendulum-like arms **52** having upper pivots **53** and roller bearings **50***a*. An arm is located at each end of the roller but only one of them is shown in the drawings. The web subsequently passes over an output roller **54** and into the press.

For the purpose of setting the amount of pressure to be exerted by the brake cylinder **21** and therefore the

average web tension, the floating roller **50** is equipped with a loading cylinder **55** having a plunger **56** arranged generally opposite the plunger **41** of the regulator. The pressure in the loading cylinder is adjusted so that a predetermined amount of web tension will keep the floating roller centered in a position of equilibrium. In the present instance the control pressure for the loading cylinder is obtained from an adjustable pressure regulator **60** fed from the supply line **34** and having an output line **63**. The pressure regulator may be of the same type as that (**31**) previously referred to, having a manual control **61** and indicator **62**. The regulator is preferably placed at a convenient position on the press and the indicator **62** is calibrated directly in terms of web tension.

In accordance with one of the features of the invention, the loading cylinder **55** is pressurized, not directly by the air in the line **63**, but through a liquid medium, preferably oil, the flow of which is restricted in both directions. Turning to Fig. 1, the air-oil interface is established in a reservoir **64** which is connected to the loading cylinder by an oil line **65**. Included in the oil line is an orifice or constriction **66**. This orifice is so constructed that the movement of the floating roller **50** takes place at a controlled rate. In the present device, which is merely exemplary, a loading cylinder is used having a diameter of three inches and the orifice, using #30 SAE oil, is $\frac{3}{32}$ inch in diameter and one inch in length.

In order to understand the operation of the variable pressure regulator **40**, reference is made to Fig. 3. Here it will be noted that the control rod **41** is mounted for telescoping movement within the regulator body and presses against the control spring **42**. This control spring in turn bears upon a diaphragm **70** which defines a pressure chamber **71**. When the pressure in the chamber **71** counterbalances the force exerted by the spring **42**, equilibrium is achieved. The pressure chamber **71** is normally connected to the output line **43** except when a red button stop is made. Such connection is accomplished by an emergency valve **67** which is connected to the regulator by lines **68**, **69**. The valve has a normal port **67***a* and an emergency port **67***b*, the ports being selectively moved into active position. It will be seen in Fig. 1 that the lines **68**, **69** are simply interconnected by the valve port **67***a* during normal running conditions.

For the purpose of bleeding air from the chamber **71** and the output line **43** when the pressure is above the set value, a valve **72** is provided having a poppet **73** and a seat member **74** which is movable with the diaphragm. The seat member **74** is hollow, being vented to the atmosphere through vents **74***a*. It will be apparent that movement of the diaphragm to the left when the pressure is above the set value will cause the valve **72** to open, thereby permitting passage of air between the seat and the poppet which is exhausted through the vents **74***a*. This passage takes place until the pressure in the output line **43** and chamber **71** drops to its equilibrium value, at which time the diaphragm is restored to its equilibrium position, cutting off further flow.

For the purpose of admitting additional air to the line **43** when the pressure therein is below the set value, a second valve **75** is provided having a poppet **76** and a seat **77**, the poppet **75** being mechanically connected to the poppet **73**. In operation a drop of pressure in the chamber **71** below the set value causes movement of the diaphragm to the right against the force of the poppet spring **83**, opening the poppet **76**. This causes replenishment of air in the output line **43** until the equilibrium pressure is reached, at which time the poppet **76** closes, cutting off further flow. The two poppets **73**, **76** are spaced so as to operate in sequence, the sequential spacing being exaggerated in the drawing for ease in understanding. This insures that the exhaust poppet **73** is completely closed when the supply poppet **75** is open. Stated in other words, the two poppets open alternatively depending upon whether the pressure is slightly below or

slightly above the equilibrium value. As a result the pressure in the output line **43** tends to remain at the set value which is determined by the degree of compression of the control spring **42** and, consequently, by the position of the control rod.

To eliminate valve area error an auxiliary piston **78** is provided which is connected to the poppet **76** by a rod **79**. The area of the auxiliary piston is so adjusted that the pressure applied to the poppet **76** by the air in the line **34** is almost exactly compensated.

In accordance with the present invention, means are provided for neutralizing the force of the control spring **42** to reduce almost to zero the amount of energy required to operate the regulator. As shown in Figs. 1 and 2, this neutralization is accomplished by providing a compensating cylinder **80** which is arranged at the opposite side of the arm **52**. The compensating cylinder has a plunger **81** and is supplied with air through a line **82** which is connected to the regulated output line **43**. The area of the piston in this cylinder and the moment arm of the plunger **81** are adjusted so that the torque exerted by the cylinder **80** exactly neutralizes the torque of the control spring **42**. For convenience in adjusting the moment arm of the cylinder **80**, the latter is provided with an adjusting screw **84** (Fig. 2).

It may be shown that the forces of the control spring **42** and the compensating cylinder **80**, once they have been balanced at a particular pressure in the output line (**43**), remain in balance for all other pressures in the operating range. Suppose, for example, that starting from a condition of balance or equilibrium there is a decrease of web tension below the set value. The resulting unbalance causes the floating roller **50** to tend to move to the right. This produces corresponding movement of the control rod **41**. Such movement causes the pressure at the output of the regulator **40** to be increased. The increased pressure is applied to the compensating cylinder **80** via line **82** and the compensating cylinder therefore assists the control rod in its further movement against the force of the control spring until the resulting increase in the output pressure causes a corresponding increase in web tension, thereby arresting and reversing the movement of the floating roller. During the reverse movement the converse takes place. In either event, the forces which must be overcome by the floating roller are reduced almost to zero.

In order to visualize the way in which the force of the compensating cylinder offsets the force of the control spring, reference is made to Fig. 4. Here the torque **83** exerted by the compensating cylinder is shown equal and opposite to the torque **84** exerted by the control spring. In the device shown in the drawings the force required to operate the regulator is approximately 300 pounds at a representative point in its range when the compensating cylinder **80** is not used. With the compensating cylinder, the force is reduced to about 4 pounds, which is the amount of force required simply to overcome friction and may be indicated by an operating band over the range of plunger movement. This force corresponds to a web tension of two pounds since the web is doubled back upon itself. A change of two pounds in web tension is accordingly required to initiate a corrective change in tension. This is desirable since it insures that the device will not operate with only negligible changes in tension, and, in any event, the two-pound force distributed over the entire width of the web is sufficiently small so that the sensitivity of the tystem is not adversely affected.

In accordance with one of the features of the invention, the regulator and associated parts are so constructed and arranged that an extremely small movement of the floating roller, on the order of $\frac{1}{8}$ to $\frac{1}{4}$ inch, is effective to increase the braking force from near zero to a safe maximum value, and stops are provided to limit the roller movement to such range. The stops in the present in-

stance are located on opposite sides of the depending arm **52** and have been designated **85, 86**. A safe maximum value of tension is that which will, under all normal conditions of operation, produce a web tension which lies somewhat below the winding tension employed in the mill where the paper was made. In the case of ordinary newsprint, the safe maximum value is about 5 lbs. per inch of web width.

Devices constructed in accordance with the above have shown a number of surprising advantages considering the simplicity of the arrangement. The system is extremely sensitive but without any tendency to overcontrol. The system is capable of correcting both long-time disturbances, for example, those resulting from changing roll diameter, as well as extremely short transients caused by an out-of-round roll of paper rotating at maximum press speed. The arrangement is particularly satisfactory for taking care of the transient disturbances resulting from the making of a paster and the percentage of successful pasters is much higher than with conventional tension control arrangements.

The reasons for the improved performance are not completely understood. One of the reasons is believed to be the two-way shock-absorbing action which has been incorporated into the loading cylinder, the shock-absorbing effect being provided by the orifice **66**. Since the orifice affects the flow of pressure fluid equally in both directions, there is no "ratcheting" or excessive build-up of force as a result of rapidly repeated transient effects such as those caused by a roll which is out-of-round. A related feature which is of great practical advantage is the limitation of movement of the floating roller to approximately one-quarter inch. This has been found to increase the rapidity of response and inherently limits the amount of momentum which can be built up in the bodily movement of the floating roller and its associated arms. I have found it of advantage to reduce the inertia of the floating roller and its associated arms to the lowest practical point, keeping in mind the necessity for maintaining the floating roller rigid over its entire length, which may be on the order of 66 inches. Specifically, it is desirable to keep the weight of the floating roller to 80 pounds or less, although heavier rollers may be tolerated without substantially sacrificing the response characteristics.

It can be shown that the present device corrects any tendency toward changes in web tension in two ways, depending upon whether the changes are of a gradual or transient nature. In the case of those changes which fall outside of the transient category, movement of the floating roller causes a resetting of the control element **41** on the variable pressure regulator, thereby causing a corrective change in the braking force applied by the cylinder **21** as previously noted. Transient changes, caused, for example, by an out-of-round roll, are not corrected in this manner because of the inertia of the roll and since it is not possible for the control system as a whole to operate at such a high cyclic rate. Instead, transient changes are absorbed by the movement of the floating roller **50**. Thus, upon a transient increase in tension due, for example, to the unrolling of the web from the low spot on the roll, the floating roller **50** is drawn to the left, shortening the loop. In moving toward the left the floating roller moves the piston in the cylinder **55** and the resultant flow of oil through the orifice **66** provides a shock-absorbing effect. Similarly, upon a decrease in tension due to unrolling the web from the high side of the roll, the web tension drops below the equilibrium value and opposite movement of the piston in the loading cylinder **55** occurs. The rapidity of movement is again dependent upon the flow of oil through the orifice **66**, the shock-absorbing action being the same in both directions. For a given travel of the floating roller the shock-absorbing action, i. e., the diameter of the orifice **66**, is made sufficiently small as to prevent hunting, yet sufficiently large so that the reactive force is below that which will cause breakage of the web when taking web from an out-of-round roll of small diameter.

While I prefer to limit the movement of the floating roller to about one-quarter inch, it will be understood that the range of movement may be somewhat greater or somewhat less than one-quarter inch without departing from the invention, and may range from approximately $\frac{1}{10}$ to approximately 1 inch. I have found that when the movement is limited to less than about $\frac{1}{10}$ inch, there is risk of hunting. Such hunting may take place at a rate of about 40 cycles per second, being dependent upon the inertia of the paper roll and the resiliency of the web. This tendency toward hunting is believed due to the resilient forces built up in shock absorbers when the range of movement is small.

Above a range of movement of about one inch, it is believed that a different set of factors comes into play. Observations show that the shock-absorbing action, i. e., the resisting force, must be increased when the range of movement of the floating roller is increased in order to preserve the anti-hunt characteristics. This increase has little effect on non-transient changes but is of extreme importance in the handling of transient changes caused, for example, by an out-of-round roll. The reason for this is that the floating roller should be free to yieldingly move in either direction in response to the cyclic changes in tension. Such yielding occurs in the present device, even in the case of rapid transients and even where the range of the floating roller is about an inch. However, where the range is substantially greater than one inch the correspondingly increased reactive force of the shock absorber may become excessive. It is believed that this is one of the factors which has caused a high percentage of web breakage in the past.

Further in accordance with the present invention, I prefer to connect the brake cylinder **21** to the high tension side **20*a*** of the brake band **20**, the low tension side **20*b*** being simply anchored as shown. I prefer also to couple a cushioning spring **87** to the high tension end of the belt. For reasons not yet completely understood, it is found that this arrangement reduces the amount of belt slap and enables a smoother control when used in combination with the control system described above. In the present device we have found that the constant of the spring **87** should be approximately 25 to 35 pounds per inch extension when used with a Phosphor-bronze belt four inches in width and when employing a brake cylinder having a normal range of up to 200 pounds of force on the loop of the belt-pulling cable.

In accordance with one of the more detailed aspects of the invention, means are provided for increasing the speed of movement of the floating roller in the loop-elongating direction as an incident to reduction in press speed. More specifically, means are provided for resiliently moving the roller to its right-hand or "increase tension" position independently of the loading cylinder **55** and its associated shock-absorber. This is accomplished in the present instance by a spring **90** which is connected to the armature of a solenoid **91**. The solenoid is operated automatically as an incident to slowing down the press, for example, by the arrangement shown in Fig. 6. In this figure the controller for the press driving motor is indicated at **92**. The controller is provided with a rack and pinion **93**, the rack being connected to a dash-pot **94** having a plunger **95** provided with a small orifice. Coupled to the dash-pot are contacts **96**, which are normally held in open position by a spring **97**. It will be apparent to one skilled in the art that movement of the controller **92** in the "decrease speed" direction causes closure of the contacts **96**, the contacts **96** being opened by the spring **97** as soon as controller movement ceases.

Closure of the contacts **96** causes bottoming of the solenoid **91**, which moves the spring **90** into its operating

position. In practicing the invention, the spring **90** preferably has a high rate on the order of 66 pounds per inch, and the spring is arranged so that it is active only over the left-hand or "light braking force" portion of the range of roller movement.

For ease in understanding the operation of the spring **90**, the characteristic of a typical spring is set forth in Fig. 5. In this figure it is assumed that the solenoid is "bottomed" and that the spring is in its active position. Under such conditions the spring is capable of applying full pressure to the arm **52** of the floating roller when the latter is at its left-hand limit of movement (as limited by the stop **85**), and capable of exerting a decreasing force as the floating roller moves to the right. To review the operation, it will be assumed that the controller **92** is moved in the "decrease speed" direction at a time when the floating roller **50** is in the left-hand portion of its range. The resulting closure of the contacts **96** causes the solenoid **91** to be operated, thereby bringing the spring **90** immediately into engagement with the arm of the floating roller, moving the latter over into its right-hand position. This causes an immediate increase in pressure of the output line **43** of the regulator, causing the belt **20** to be tensioned, thereby forestalling any tendency of the roller **12** to over-travel and causing the kinetic energy of the roller to be quickly absorbed.

During the above sequence, the arm **52** of the floating roller is moved to the right independently of the loading cylinder **55**, and the arm **52** may actually move out of contact with the cylinder plunger **56**, due to the fact that the movement of the plunger **56** is retarded by the shock-absorbing effect of the orifice **66**. As a result, the system includes the advantages of the shock-absorbing action without the usual disadvantages, the shock-absorbing effect being superseded upon a reduction in press speed. It is to be noted that the action of spring **90** does not interfere with normal tension control by the floating roller. Thus, as soon as the spring **90** has moved the floating roller into the right-hand portion of its range, which occurs very quickly, on the order of a fraction of a second, the floating roller continues in complete control of the tension. The function of the spring **90** is to move the floating roller over without delay to the position which it must occupy in order to produce the increase in braking force which is required by the slowdown of the press. When the controller **92** reaches its new position, the contacts **96** are opened, thereby deenergizing the solenoid **91**, retracting the spring **90** out of its active position.

In describing the operation of the spring **90** it has been assumed that the floating roller is in the left-hand portion of its range of movement at the time that the speed controller is moved in the "decrease speed" direction. This is a rather extreme case and under more average conditions it is likely that the floating roller will be in the center portion of its range of movement at the time that a reduction in press speed is initiated. The only difference is that under the latter condition the force applied by the spring **90** to the floating roller is proportionately reduced. Should the floating roller already be in the right portion of its range at the moment that a decrease in speed is initiated, the spring **90** will have substantially no effect. In short, the amount of force exerted upon the floating roller by the spring **90** is tailored automatically to the job which must be done.

The above control system is particularly well adapted for making a red button stop under emergency conditions. For this purpose, an emergency solenoid **98** is provided for operating the emergency valve **67**. The solenoid is under the control of the red button **99**. It will be understood that the red button **99** is a part of the control system normally associated with a printing press, and may be any switch used for shutting down the press under emergency conditions whether operated manually or automatically as by a web brake detector.

When the red button is operated, the valve **67** is switched to its alternate condition set forth in Fig. 7 in which the valve port **67***b* connects the line **68** (from the regulator **40**) to exhaust, and simultaneously blocks flow of air through the line **69**. The effect of this may be readily seen by reference to Fig. 3. Exhausting the chamber **71** causes the diaphragm **70** to move all the way to the right under the influence of the spring **42**. This closes the valve **82** and opens the valve **75**, so that the full pressure of the air in the reservoir **35** is applied to the brake cylinder **21**. This causes the belt **20** to slow down the roll **12** in a minimum amount of time.

In spite of the rapid braking of the roll **12**, the degree of braking force is precisely controlled so that tearing of the web is substantially eliminated. This is accomplished by an appropriate adjustment of the pressure regulator **31**. It will be apparent, therefore, that the regulator **31** performs two functions. In the first place, it insures precise pressure regulation of high pressure air which is supplied to the pressure regulator **40** and to the regulator valve **60**. In addition, it insures that the braking force on the paper roll matches the braking force applied to the press by the normal press drive mechanism so that the press and paper roll stop in unison with one another and with reasonable web tension. The adjustment of the regulator to accomplish the latter function is well within the skill of the art.

For the purpose of slacking off the belt **20**, a 3-way shut-off valve **100** is placed in the line **43**.

Résumé of operation

While the operation of the device will be apparent from the foregoing, it may be helpful to summarize it briefly:

Prior to starting up the press, the pressure regulator **60** may be set to the point of desired web tension. This tension is maintained by the control arrangement during acceleration and after the press comes up to speed. In the event that tension in the web momentarily drops below the desired value, the balance of forces at the floating roller is upset and the roller tends to swing bodily to the right under the urging of the loading cylinder **55**. This results in inward movement of the control rod **41**, which changes the setting of the variable pressure regulator **40**. The latter produces a slightly higher output pressure, which is applied both to the brake cylinder **21** and to the compensating cylinder **80**. The increase in the force exerted by the compensating cylinder exactly overcomes the opposing force of the spring **42** so that the floating roller is perfectly free to move. The increased pressure at the brake cylinder causes a correspondingly increased braking force on the roll **12**. The resulting increase in web tension causes the floating roller to move leftward to its initial equilibrium position. The converse sequence of events occurs when the tension in the web increases above the set value for any reason.

When slowdown is initiated by the press speed controller **92**, the roll **12**, because of its momentum, tends to continue rotation at its initial speed. This tends to remove tension momentarily from the web, and the floating roller is therefore free to move to the right (Fig. 1) under the influence of the loading cylinder **55**. However, because of the constriction at the input of the loading cylinder, there is a slight time delay. The effect of such delay is, however, completely overcome by closure of the contacts **96** (Fig. 6), which causes immediate movement of the auxiliary spring **90** to the active position. This urges the floating roller toward the right independently of movement of the plunger in the loading cylinder. Such movement, acting upon the variable pressure regulator, causes immediate flow of air into the belt actuator and an immediate increase in braking pressure, thereby absorbing the excess energy stored in the roll and insuring against temporary loss of tension in the web. After the floating roller has been moved to the right-hand portion

of its range by the spring **90**, the function of the spring is completed even though it may not return immediately to its inactive position, and the floating roller continues its automatic control of web tension.

When it is necessary to press the red button **99** in an emergency to stop the press, closure of the contacts actuates the valve **67** to disable the variable pressure regulator **40** and to apply air from the line **34** directly to the belt actuator **21**. The amount of braking under such conditions is limited by the adjustment of the regulator **31** to a point below that which will cause breakage of the web.

Since the system is substantially closed, loss of pressure fluid air in the present instance is kept to a minimum. Furthermore, due to the fine degree of control the traverse of the control element and the brake cylinder is minimized. For these and other reasons which will be apparent to one skilled in the art, the energy requirements of the arrangement are lower than in more conventional tension control systems.

Because of the simplicity of the arrangement, adjustment and maintenance are both kept to a minimum. The only adjustment required on the part of the press operator is the setting of the regulator **60** directly in terms of desired web tension.

This application is a continuation-in-part of copending application Serial No. 304,405, filed August 14, 1952.

I claim as my invention:

1. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a spring-returned control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, means responsive to the output pressure of the regulator for neutralizing the force of the spring, a floating roller for engaging a loop in the running web, means including a source of adjustable bias for mounting said roller for bodily movement in response to changes in loop tension, means for coupling the control element of the regulator to said roller so that a departure in the tension in the loop from its adjusted equilibrium value causes a corrective change in braking force, said regulator being so constructed and arranged that less than about one-quarter of an inch of roller movement is effective to increase the braking force from substantially zero to a safe maximum value, and stops for limiting the movement of the floating roller substantially to such range.

2. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a pressure regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means including a source of adjustable bias for mounting said roller for bodily movement in response to changes in loop tension, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, said regulator and actuator being so constructed and arranged so that the braking force is varied between maximum useful limit conditions by movement of the floating roller within a range having a width which is not less than one-tenth inch nor greater than one inch, and stops for limiting the movement of the floating roller to such range.

3. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means including a source of adjustable bia for mounting said roller for bodily movement in respons to changes in loop tension, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, and stops for limiting the range of movement of the floating roller to about one-quarter of an inch.

4. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator coupled to the high tension end of said belt for tensioning the latter, a first variable pressure regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder for biasing said roller mounting means in a direction to elongate the loop a second variable pressure regulator having a manual adjustment for adjusting the pressure in the loading cylinder, and means for coupling the control element of the first regulator to said roller so that a change in tension in the loop from the equilibrium value determined by said loading cylinder causes a corrective change in braking force.

5. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator coupled to the high tension and of said belt for tensioning the latter, a source of pressure fluid at constant pressure, a variable pressure regulator having a control element and having a connection with said constant pressure source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, biased means for mounting said roller for bodily movement in response to changes in loop tension, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, and means including a "red button stop" control for disabling said regulator and for connecting the actuator for direct supply from said constant pressure source.

6. In a tension system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator coupled to the high tension end of said belt for tensioning the latter, a source of pressure fluid having a constant pressure regulator, a variable pressure regulator fed from said constant pressure regulator, said variable pressure regulator having a movable control element and arranged to supply pressure fluid to said actuator at a variable pressure in accordance with the positioning of the control element, a floating roller for engaging a loop in the running web, biased means for mounting said roller for bodily movement in response to changes in loop tension, means for coupling the control element of the variable pressure regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, means including a "red button stop" control for disabling said variable pressure regulator

and for connecting the actuator directly to the output of said constant pressure regulator, and means on said constant pressure regulator for adjusting the output pressure thereof to a value below that which will cause breakage of the web.

7. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop elongating direction, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, and means arranged to be actuated during slowdown of the printing press for applying additional bias to said roller mounting means.

8. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having a manually adjustable source of pressure fluid for biasing said roller mounting means in a direction to elongate the loop, and means for coupling the control element of the regulator to said roller so that a change in tension in the loop from the equilibrium value determined by said loading cylinder causes a corrective change in braking force, said loading cylinder having a constriction at its input to impede the free flow of fluid and thereby provide a limited amount of shock-absorbing action for said floating roller.

9. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a movable control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for limited bodily movement between a short loop position and a long loop position in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop-elongating direction, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, said loading cylinder having damping means connected thereto to damp its movement in response to applied fluid pressure, and means arranged to be actuated upon initiating slowdown of the printing press for forcibly moving said floating roller out of its short loop position independently of movement of said loading cylinder.

10. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a movable control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop-elongating direction, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, said loading cylinder having a damping element connected thereto to impede the free flow of fluid to and from the loading cylinder, and means arranged to be actuated upon initiating slowdown of the printing press for applying pressure fluid to said actuator independently of the movement of said loading cylinder.

11. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a movable control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop-elongating direction, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, said loading cylinder having a two-way shock-absorber connected thereto to damp the movement thereof, and means arranged to be actuated upon initiating slowdown of the printing press for forcibly moving said floating roller in a direction to elongate the loop.

12. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a movable control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop-elongating direction, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in the braking force, said loading cylinder having a constriction at its input to impede the free flow of fluid to and from the loading cylinder, and means arranged to be actuated upon initiating slowdown of the printing press for forcibly moving said floating roller in a direction to elongate the loop.

13. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a movable control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position

of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop-elongating direction, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, said loading cylinder having a damping element connected thereto for damping the movement thereof, an auxiliary spring movable between a retracted position and an active position in which it pressingly engages the roller mounting means to force the same in the loop-elongating direction, said spring having a high spring rate so that the pressure exerted thereby varies from a relatively high value to zero within the range of movement of the floating roller, and means arranged to be actuated upon initiating slowdown of the printing press for moving said spring into its active position to cause movement of the floating roller in the loop-elongating direction independently of any delay in the movement of said loading cylinder.

14. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a stationary belt peripherally engaging the roll to apply a braking force thereto and having a low tension end and a high tension end, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension and biased in a direction to elongate the loop, means for coupling the control element of the regulator to said roller so that a change in tension in the loop causes a corrective change in braking force, said actuator being connected to the high tension end of the belt and having an associated spring for cushioning the braking force.

15. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure fluid regulator having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means including a pendulous hanger for mounting said roller for bodily movement in response to changes in loop tension, means including a loading cylinder having an adjustable source of fluid pressure for biasing the hanger in a direction to elongate the loop, means for coupling the control element of the regulator to said roller so that a change in tension in the loop from that corresponding to the setting of the loading cylinder causes a corrective change in braking force.

16. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pneumatic actuator connected to said belt for tensioning the same, a variable pneumatic pressure regulator having a control rod and a control spring therefor and in which the output pressure is a direct function of the force applied to the control rod, means for connecting the pneumatic actuator to the output of said regulator, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement and having means for biasing the roller in a direction to increase the size of the loop, means for coupling the control rod of the regulator to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, and means for counterbalancing the control spring in all positions of the control rod.

17. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pneumatic actuator connected to said belt for tensioning the same, a variable pneumatic pressure regulator having a control rod and a control spring therefor and in which the output pressure is a direct function of the force applied to the control rod, means for connecting the pneumatic actuator to the output of said regulator, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement and having means for biasing the roller in a direction to increase the size of the loop, a compensating cylinder connected to the output of said regulator for applying pressure to the control rod which is substantially equal and opposite to the force exerted by the control spring, and means for coupling the control rod of the regulator to said roller so that a change in tension in the loop causes a corrective change in braking force.

18. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pneumatic actuator connected to said belt for tensioning the same, a pneumatic pressure regulator having a control rod and in which the output pressure varies in proportion to the displacement of the control rod, means for connecting the pneumatic actuator to the output of said regulator, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement, a loading cylinder for biasing the roller mounting in a direction to enlarge the loop, said loading cylinder being filled with oil and having an adjustable source of air pressure in contact with the oil, and means for coupling the control rod of the regulator to said roller so that a change in tension in the loop from the equilibrium position determined by said loading cylinder causes a corrective change in braking force.

19. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure device having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means including a loading cylinder for mounting said roller for bodily movement in response to changes in loop tension, means for coupling the control element of the pressure device to said roller so that a departure in the tension in the loop from its adjusted equilibrium value causes a corrective change in braking force, said pressure device being so constructed and arranged that movement of the floating roller over a range of at least one-tenth of an inch but not more than a range of about one inch is effective to increase the braking force from substantially zero to a safe maximum value, and stops for limiting the movement of the floating roller substantially to such range.

20. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure device having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means in-

cluding a source of adjustable bias for mounting said roller for bodily movement in response to changes in loop tension, means for coupling the control element of the pressure device to said roller so that a departure in the tension in the loop from its adjusted equilibrium value causes a corrective change in braking force, said pressure device being so constructed and arranged that less than about one inch of roller movement is effective to increase the braking force from substantially zero to a safe maximum value, stops for limiting the movement of the floating roller substantially to such range, and two-way shock absorber means coupled to the floating roller, said shock-absorbing means being so adjusted as to enable the floating roller to yield to changes in tension resulting from unrolling the web from a low spot on an out-of-round roll without exceeding the breaking stress of the web.

21. In a tension control system for a printing press for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator connected to said belt for tensioning the latter, a variable pressure device having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder having an adjustable source of fluid pressure for biasing said roller mounting means in the loop-elongating direction, means for coupling the control element of the pressure device to said roller so that

a change in tension in the loop from an equilibrium value causes a corrective change in braking force, and means arranged to be actuated during slow down of the printing press for moving the roller mounting means into the portion of its range of movement corresponding to increased braking pressure but leaving said roller free for movement in such portion of its range.

22. In a tension control system for maintaining a desired tension in a running web fed from a paper roll, the combination comprising a brake belt peripherally engaging the roll to apply a braking force thereto, a pressure fluid actuator coupled to one end of said belt for tensioning the latter, a variable pressure device having a control element and having a connection with a source of pressure fluid for applying fluid to said actuator at a pressure corresponding to the position of the control element, a floating roller for engaging a loop in the running web, means for mounting said roller for bodily movement in response to changes in loop tension, a loading cylinder for applying an adjustable biasing force to said roller mounting, means for coupling the control element of the pressure device to said roller so that a change in tension in the loop from an equilibrium value causes a corrective change in braking force, and a two-way shock absorber coupled to said loading cylinder for providing controlled yielding movement of the latter in response to transient changes in tension.

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