Aug. 25, 1964 R. LE BARON BOWEN, JR 3,145,945

TENSION CONTROL APPARATUS

Filed Feb. 15, 1963

2 Sheets-Sheet 1

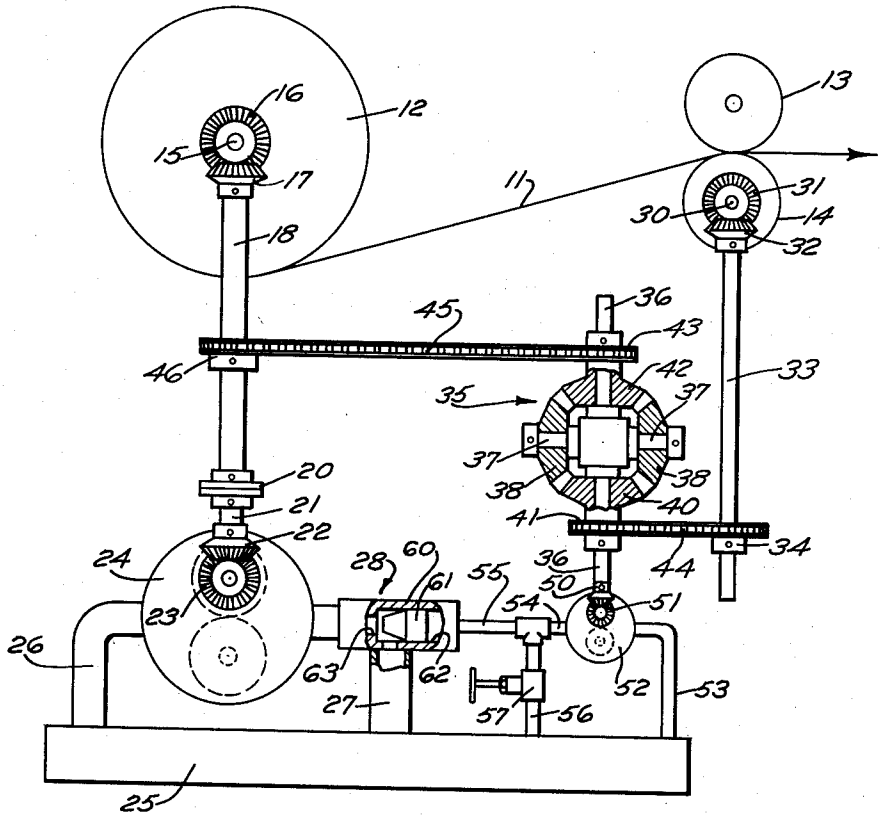


FIG. 1

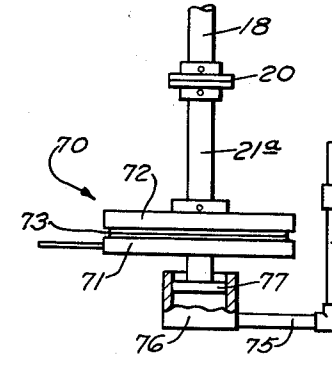


FIG. 2

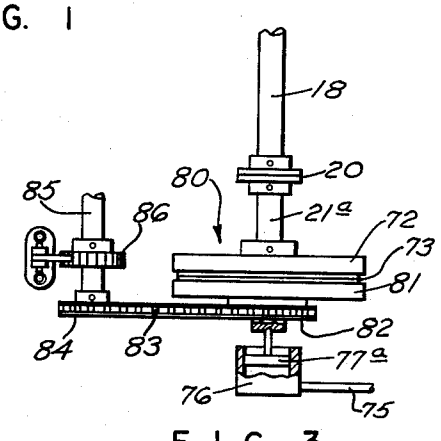


FIG. 3

INVENTOR.

RICHARD LE BARON BOWEN, JR.

BY

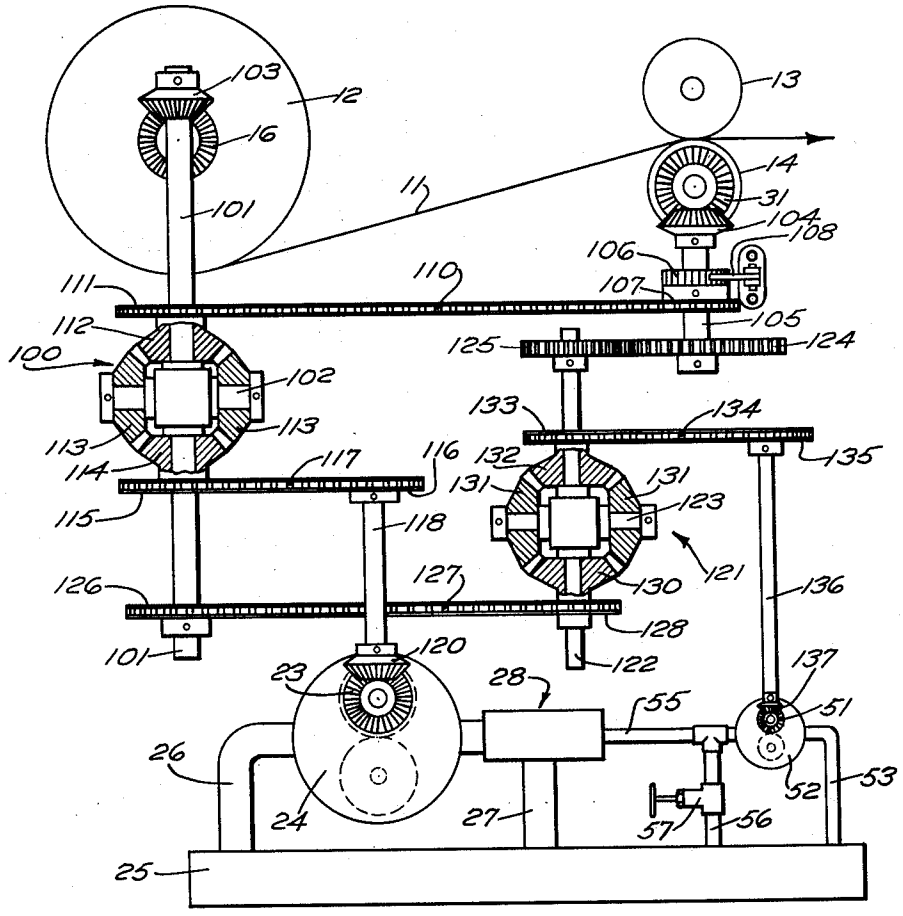
Barlow & Barlow

ATTORNEYS

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INVENTOR.

RICHARD LE BARON BOWEN, JR

BY

Barlow & Barlow

ATTORNEYS

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3,145,945

TENSION CONTROL APPARATUS

Richard Le Baron Bowen, Jr., 35 Fessenden Road, Barrington, R.I.

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This invention relates to a brake mechanism for applying tension to an unwinding strip or strand of material, and more particularly to a brake mechanism which will automatically maintain a uniform tension on the material.

The primary object of the present invention is to provide a brake mechanism for unwinding rolls of material which will automatically apply a uniform tension to the material being pulled from the rolls, irrespective of the change in diameter of the rolls.

Another object of the present invention is to provide a brake mechanism for unwinding rolls which will automatically maintain uniform tension without the use of feed-back sensing controls touching the material being unwound.

Still another object of the present invention is to provide an automatic tension control brake which is mechanically simple, yet rugged and positive in action.

A further object of the present invention is to provide a brake mechanism for unwind tension control wherein the control element consist of a hydromechanical system consisting of a simple mechanical differential gear train and a fluid pump.

A still further object of the present invention is to provide an unwind brake mechanism which does not have to be re-set for the start of each new roll.

Another object is to provide a combination unwind/wind-up control device.

Other objects of the present invention will be pointed out in part and will become apparent in part in the following specification and claims.

Many industries, such as the textile, paper, metal, rubber and plastics, have processes which handle the material in process in the form of rolls of the material. These rolls are fed through various processes and it is usually a prerequisite to maintain tension on the material as it leaves the roll and is drawn into the process machinery. Often a simple mechanical brake is used. However, as the roll of material decreases in diameter, its speed increases since the process is run at a constant speed. This speeds up the rotation of the mechanical brake, and since the brake produces constant torque unless its setting is changed it will produce more horsepower and thus put more tension on the material. In such a case tension increases directly with the increasing revolutions of the unwinding roll, or inversely with the decreasing diameter of the roll. Manual control of such a simple mechanical brake requires an operator to constantly reduce the brake setting in an attempt to keep the tension uniform. Such contorl is crude under any conditions. Many devices have been provided in attempts to automatically control the tension on an unwinding roll of material. These have been mechanical, electrical, and hydraulic. However, most are complicated, have poor performances, and costly to maintain, and most objectionably many require that they be re-set for the start of a new roll.

The present invention is designed as a simple unwind control brake mechanism which is fully automatic and does not need to be re-set. Its control system consists of a simple mechanical differential gear train coupled with the most elementary fluid system possible: a pump with control valve.

Referring to the drawings in which similar characters of reference indicate corresponding parts in the figures:

FIGURE 1 shows an embodiment of the present invention in diagrammatic form;

FIGURE 2 shows a modification of part of FIGURE 1;

FIGURE 3 shows a further modification similar to FIGURE 2; and

FIGURE 4 represents another embodiment of the present invention in diagrammatic form, actually representing a modification of FIGURE 3.

Referring to the drawings in more detail, particularly FIGURE 1, a strip or web of material is withdrawn from storage or parent roll 12 at a constant linear velocity by means of nip rollers 13 and 14, roller 14 being driven at a constant speed by means not shown. Roll 12 is fixed to mandrel 15 which has fixed to it a bevel gear 16 which meshes with bevel gear 17 fixed to shaft 18. Shaft 18 is coupled by means of coupling 20 to shaft 21 which has fixed to it bevel gear 22 which meshes with bevel gear 23 fixed to the input shaft of "bull" pump 24. Bull pump 24 draws fluid from reservoir 25 through suction line 26 and discharges it through return line 27 leading from servo-valve 28.

Driven roller 14 has fixed to a shaft extension 30 a bevel gear 31 which meshes with bevel gear 32 fixed to shaft 33 which also has fixed to it sprocket 34. A differential gear train, generally indicated by character 35, is composed of main shaft 36, idler shaft 37, idler gears 38, input gear 40 with input sprocket 41 rotatably mounted on shaft 36, and input gear 42 with input sprocket 43 rotatably mounted on shaft 36. Idler gears 38 mesh with input gear 40 and output gear 42. Input sprocket 41 is driven by sprocket 34 on shaft 33 by means of chain 44. Output sprocket 43 is connected by means of chain 45 to sprocket 46 fixed to shaft 18. The differential thus comprises three elements, namely, the input element 40, the input element 42 and the main shaft with its idlers as an element.

Shaft 36 of differential 35 has fixed to it bevel gear 50 which meshes with bevel gear 51 fixed to the input shaft of pilot-pump 52 having a suction line 53 connecting with reservoir 25. Pilot pump 52 is provided with discharge line 54 which has a branch 55 leading to servo-valve 28, and a return line branch 56 leading to the reservoir 25 through a throttling valve 57.

Servo-valve 28 consists of housing 60 with bore 62 for slidably holding shuttle 61. One end of bore 62 is reduced as at 63 to provide a seat for the tapered plug end of shuttle 61. It is apparent that this particular form of valve is used purely by way of illustration, and that any form of pilot-operated servo-valve can be used.

In operation, nip rollers 13, 14 revolve at a constant speed withdrawing strip 11 from roll 12. The rotation of roll 12 by the tension in strip 11 causes bull pump 24 to rotate through the gearing on shafts 18, 21. Rotation of shaft 33 driven by roller 14 causes input gear 40 of differential 35 to rotate. Shaft 18 through roll 12 drives gear 42 through sprockets 46, 43. There is always a difference in speed between gears 40, 42 regardless of the size of roll 12. This speed difference causes shaft 36 to rotate, thereby causing pilot pump 52 to operate. Pilot pump 52 pulls fluid in through line 53 and discharges it through line 54. The throttling valve 57 is the main control on this device, and effectively controls the tension on unwinding strip 11. Throttling valve 57 produces back pressure in line 54 and this pressure is transmitted to the right side of servo-valve 28 by means of line 55. Bull pump draws fluid through line 26 and discharges it through passage 63 to return line 27. Shuttle 61 is urged towards the seat provided by restricted passage 63 so that the pressure in bore 62 times the area of bore 62 is balanced by the pressure in passage 63 times

the area of passage 63. In a valve of the configuration shown, the pressure in passage 63 will have to be greater than that in line 55 for equilibrium to take place. It is evident that, regardless of the pressure in line 55, the pressure in passage 63 will be proportional to it, and may be calculated by multiplying the pressure in line 55 by some factor such as K. Other servo-valves could be provided such at K is equal to 1 or less than 1, rather than greater than 1 as in the illustrated case of servo-valve 28 in FIGURE 1.

As roll 12 unwinds its diameter becomes increasingly smaller so that the speed of mandrel 15 likewise increases, inasmuch as strip 11 is withdrawn as a constant linear velocity. As roll 12 speeds up, shaft 18 and sprocket 46 turn faster, thereby tending to speed up gear 42. This slows down shaft 36 thereby slowing down pilot pump 52. Throttling valve 57 acts as a fixed restriction in discharge line 56 so that as pilot pump 52 slows down the pressure in line 55 decreases. This reduces the pressure in passage 63 proportionally. If the pressure in passage 63 were not changed as roll 12 unwound and bull pump 24 speeded up, the torque produced by bull pump 24 would increase proportionally to the speed increase and this would increase the tension in strip 11 proportionally. However, with the present invention, as the speed of bull pump 24 increases the pressure in passage 63 on the discharge of bull pump 24 decreases so that the torque on the bull pump 24 decreases, thereby tending to maintain the tension on strip 11 at a more or less uniform value, rather than increasing it constantly. The tension at any point in the unwind history of roll 12 may be adjusted by adjusting throttling valve 57.

FIGURE 2 shows a modification of FIGURE 1, wherein bull pump 24 is replaced by a mechanical brake generally indicated by reference character 70, with element 71 fixed against rotation and rotating element 72 with lining 73 fixed to shaft 21*a* connected to coupling 20. Shaft 18 and all other operating parts are as shown in FIGURE 1, including pilot pump 52 and pressure line 55. However, in FIGURE 2 pressure line 55 leads to servo-valve 28*a*, a modification of the original servo-valve 28 shown in FIGURE 1. Servo-valve 28*a* is basically the same as servo-valve 28, except that it is designed for handling gas (air) rather than liquids, and therefore has ports 74 for exhausting the fluid to the surroundings. A line 75 connects servo-valve 28*a* to cylinder 76 fitted with piston 77 fixed to stationary brake element 71. Connected to line 75 is line 78 with valve for introducing fluid to line 75 and cylinder 76. The pressure in cylinder 76 is controlled by the throttling action of servo-valve 28*a*.

In operation the mechanism shown in FIGURE 2 operates much the same as FIGURE 1. As the roll unwinds pilot pump 52 slows down pumping less fluid through valve 57 thereby reducing the pressure in line 55 leading to servo-valve 28*a*, likewise reducing the throttled fluid pressure in line 75 and cylinder 76. This effectively reduces the torque applied by brake 70 to roll 12, thereby tending to maintain the tension in strip 11 more or less uniform.

FIGURE 3 shows a further modification in which brake 70 has been replaced by a slip clutch 80 so that the mechanism may be used for unwinding a roll and then reversing the process machinery and winding up the roll. Slip clutch 80 has a rotatable element 72 fixed to shaft 21*a* as in FIGURE 2. Opposing clutch element 81 has fixed to it a sprocket 82 which is connected by chain 83 to sprocket 84 fixed to shaft 85. Shaft 85 is a power input shaft with a ratchet 86 to permit rotation in only one direction.

In operation it is necessary to consider two conditions in FIGURE 3, one when unwinding a roll and two when winding up a roll from a starting core. When FIGURE 3 is run as an unwind, its operation is identical to FIGURE 2, since ratchet 86 prevents shaft 85 and clutch element 81 from rotating, so that clutch 80 is for all intents and purposes a mechanical friction brake as in FIGURE 2. Piston 77*a* urges element 81 towards element 72 just as piston 77 urges element 71 towards rotating element 72 in FIGURE 2. When the mechanism works as a windup drive, rollers 13, 14 in FIGURE 1 rotate so as to feed strip 11 to roll 12. Shafts 33, 18 and differential 35 all rotate in a direction opposite from when the mechanism is used in unwinding. In this instance when the device is used as an unwind-windup drive, pilot pump 52 must be of the reversible type wherein rotation in either direaction produces flow through line 54 to pressurize line 55. As a windup, pilot pump 52 progressively speeds up as the roll 12 increases in diameter, producing increasing pressure in line 55 so that servo-valve 28*a* produces progressively higher pressures in line 75 thereby increasing the torque applied by clutch 80 as roll 12 winds up, maintaining the tension in the strip 11 more or less uniform. Power input shaft 85 could be driven by an electric motor which would be energized when roll 12 was winding up, but would not be energized when roll 12 was unwinding. Or power input shaft 85 could be driven from roller 14 with a suitable one way clutch installed so that no motion would result when rollers 13, 14 were withdrawing strip 11 from roll 12.

FIGURE 4 shows a modification of FIGURE 3 and as such is a further modification of FIGURE 1. In FIGURE 4 the slip clutch 80 of FIGURE 3 has been replaced by a differential gear train generally indicated by 100 and tension pump 24. Differential 100 is mounted on shaft 101 with cross shafts 102. Fixed to shaft 101 at one end is gear 103 meshing with gear 16 fixed to the mandrel of roll 12. Fixed to roller 14 is gear 31 which meshes with gear 104 fixed to shaft 105. Also fixed to shaft 105 is one element of overrunning clutch 106 which is additionally provided with ratchet 108. Sprocket 107 is fixed to the other element of overrunning clutch 106 and is connected by means of chain 110 to sprocket 111 fixed to gear 112 rotatably mounted on shaft 101. Gear 112 meshes with gears 113 rotatably mounted on shafts 102 and gears 113 mesh with gear 114 rotatably mounted on shaft 101. Sprocket 115 fixed to gear 114 connects by means of chain 117 with sprocket 116 fixed to shaft 118 which has fixed to it gear 120 which meshes with gear 23 on tension pump 24.

A second differential gear train generally indicated by 121 is mounted on shaft 122 with cross shafts 123. Power input to differential 121 is from gear 124 fixed to shaft 105 and gear 125 fixed to shaft 122. Differential 121 is connected to shaft 101 by means of sprocket 126 which by means of chain 127 drives sprocket 128 fixed to gear 130 rotatably mounted on shaft 122. Gear 130 meshes with idler gears 131 which mesh with gear 132 rotatably mounted on shaft 122. Gear 132 has fixed to it a sprocket 133 which by means of chain 134 is connected to sprocket 135 fixed to shaft 136 which has fixed to it gear 137 which meshes with gear 51 fixed to the input shaft of pilot pump 52. In this case both tension pump 24 and pilot pump 52 are of the reversible type such that regardless of the rotation of their input shafts discharge is in the same direction. The fluid system connecting pumps 24, 52 is identical to that shown in FIGURE 1 in all other respects.

In operation of FIGURE 4 we have two conditions to consider as in FIGURE 3. First consider that the mechanism is being used as an unwind control so that rollers 13, 14 which are powered by a source (not shown) are turning in such a direction so as to withdraw strip material 11 from roll 12. When turning in this direction ratchet 108 is locked so that shaft 105 rotates and sprocket 107 remains stationary holding gear 112 on differential 100 from rotating. With gear 112 fixed against rotation differential gear train 100 simply becomes an idler gear train with a fixed ratio. Thus tension pump 24 will be turned in direct proportion to the speed of shaft 101,

which in turn has a speed proportional to the diameter of roll 12. Therefore, when acting as an unwind mechanism FIGURE 4 is identical to FIGURE 1 since the gear train 100 does not act as a differential but rather as a simple gear train with one input and one output.

It is when used as a wind-up mechanism that the differential 100 in FIGURE 4 comes into use. In such a case, rollers 13, 14 are driven by a source of power (not shown) and turn in such a direction as to feed strip 11 to roll 12. In this case overrunning clutch 106 drives sprocket 107 and thus input gear 112 of differential 100. When power is put into gear 112 this produces reaction torque on both shaft 101 and shaft 118. Since shaft 101 must turn at a predetermined speed to wind up the roll 12, pump 24 is forced to turn at a specific speed. As roll 12 winds up its speed decreases thereby increasing the speed of tension pump 24. Differential 121 acts as described in FIGURE 3 so that as pump 24 speeds up pilot pump 52 also speeds up thereby automatically increasing the back pressure on tension pump 24 and tending to maintain the tension in strip 11 more or less constant.

I claim:

1. In an unwinding apparatus, a roll of material, means for withdrawing said material, a brake mechanism for applying a drag on said roll, a driving connection between said roll and said brake mechanism, a differential gear train comprising three rotatable power transmitting elements, a driving connection between the first of said elements and said means for withdrawing said material, a driving connection between the second of said elements and said roll, a fluid pump, a control valve in the discharge of said pump for producing back pressure, a driving connection between the third of said elements and said fluid pump, and means whereby the pressure produced by said pump controls the amount of drag applied by said braking mechanism.

2. In an unwinding apparatus, a roll of material, means for withdrawing said material, a brake mechanism for applying drag on said material, a driving connection between said roll and said brake mechanism, a differential gear train comprising three rotatable power transmitting elements, a driving connection between the first of said elements and said means for withdrawing said material, a driving connection between the second of said elements and said roll, a fluid pump, means for throttling the discharge from said pump to produce a back pressure, a driving connection between the third of said elements and said fluid pump, and means whereby the pressure produced by said pump controls the amount of drag applied by said braking mechanism.

3. An apparatus as in claim 2 wherein said brake mechanism is a second fluid pump.

4. An apparatus as in claim 2 wherein said brake mechanism is a mechanical brake.

5. An apparatus as in claim 2 wherein said brake mechanism is a second fluid pump and said means for controlling the drag is a servo-valve in the discharge of said second pump, said servo-valve being actuated by the pressure on said first pump.

6. In an apparatus for winding or unwinding, a roll of material, means for withdrawing said material from said roll or for feeding said material to said roll, a slipping drive mechanism comprising an input shaft and an output shaft, said slipping drive connection being capable of producing variable torque, means for driving said input shaft when said apparatus is used for winding, means for locking said input shaft when said apparatus is used for unwinding, a driving connection between said output shaft and said roll, a differential gear train comprising three rotatable power transmitting elements, a driving connection between the first of said elements and said means for withdrawing said material or for feeding said material, a driving connection between the second of said elements and said roll, a fluid pump, means for throttling the discharge from said pump to produce back pressure, a driving connection between the third of said elements and said fluid pump, and means whereby the pressure produced by said pump controls the amount of torque produced by said slipping drive connection.

7. An apparatus as in claim 6 wherein said slipping drive connection consists of a slip clutch.

8. An apparatus as in claim 6 wherein said slipping drive connection consists of a second differential gear train with a second fluid pump connected to one of the three power transmitting elements of said second differential.

9. An apparatus as in claim 6 wherein said slipping drive connection consists of a second differential gear train with a second fluid pump connected to one of the three power transmitting elements of said second differential, and said means for controlling the torque consists of a servo-valve in the discharge of said second pump, said servo-valve being actuated by the pressure produced by said first pump.

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