CONSTANT TENSION TAKE-UP AND LET-OFF MECHANISM

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Inventor:
Howard H. Haworth
By: Soane Painter & Anderson
Off.
The present invention relates in general to wire take-up and let-off mechanisms, and more particularly to a take-up and let-off mechanism which is operable to reel wire coming from, or unreel wire going to, a wire processing machine and to maintain such wire at a constant predetermined tension.

In many different types of wire processing machines, the wire must be fed to or drawn from such machines at a constant controlled tension; for example, wire which is being covered or jacketed in an extruding machine must be drawn from the extruding machine at a constant controlled tension, and this constant tension must be maintained as the jacketed wire is wound on a take-up reel. In this case, the jacketed wire must be wound on the take-up reel at a very low tension so as not to flatten the jacket on the wire. This operation is complicated since the wire emerges from the extruding machine at a constant rate of speed whereas the winding diameter of the take-up reel increases as the wire is wound thereon.

Various mechanisms have been suggested for adjusting the tension on a wire during reeling and unreeling. In one such system, the torque of the motor which controls the take-up reel is controlled between two selected points of operation by the actual tension exerted on the wire. In this system, a given tension is placed on the wire for a short interval and then a second tension is placed on the wire for a short interval, these tensions alternating during the entire take-up operation. This system is unsatisfactory since the change-over from lower tension to higher tension produces alternately loosely wound and tightly wound layers of wire on the reel. The tight windings may damage the jacket on the wire or if fine jacketed wire is being reeled, the wire in the tightly wound layers may pull down into the loosely wound layers, thereby producing a reel of wire from which it is difficult to unwind the wire.

In another system, the wire passes over a fixed pulley, a floating pulley, and then over a pivotally mounted pulley before being received on the take-up reel. This arrangement provides a loop of wire of adjustable dimension, depending upon the position of the floating pulley. A weight affixed to the floating pulley provides a predetermined tension on the wire. Means operable by the weighted pulley upon contraction or expansion of the adjustable loop alternately decreases and increases the speed of the take-up reel motor. In this unit, the pulley is arranged to alternately trip a toggle switch which controls the energization of an electric commutator associated with the take-up reel motor so as to cause the motor to operate on either of two preselected speed torque curves. Although this system operates to provide a uniform tension on the wire when the wire is being drawn from a wire processing machine which is operating at full speed operation, other means must be provided to maintain the uniform tension on the wire during an initial starting period of the wire processing apparatus. This may be accomplished, for example, by extending the shaft from the take-up reel motor and connecting the extended shaft portion to a clutch which can connect the take-up reel to the motor which controls the paying out of the wire from the wire processing machine. This would produce a uniform tension on the wire during the start-up period of the wire processing machine if the winding diameter of the take-up reel is such that its peripheral speed equals the peripheral speed of the last step of a capstan which pays out the wire from the wire processing machine.

The present invention overcomes the difficulties and complexities encountered in the above mentioned tension controlling systems and provides a simple mechanism for reel and unreel wire at a uniform controlled tension, the device being mechanically and electrically independent of the processing machine with which it may be associated.

The objects of the present invention are to provide a constant tension take-up and let-off mechanism for use in conjunction with a wire processing machine; to provide such a mechanism which does not require synchronization either mechanical or electrical to the processing machine with which it is associated; to provide a constant tension mechanism for reel and unreel wire which is portable and which may be used interchangeably with various standard wire processing machines; to provide a constant tension mechanism which may take up or let off wire at very low tensions; and to provide a constant tension take-up and let-off mechanism which will follow the changes of speed of the processing equipment with which it is used over a wide range of speeds.

Further objects and advantages of the present invention will be apparent from the following description and accompanying drawings which illustrate one form of the invention.

In the drawings:
Figure 1 is a side elevational view of a take-up and let-off mechanism constructed in accordance with the present invention, a portion thereof being cut away to show some of the underlying structure. The mechanism illustrated in this figure is arranged for reeling up wire from a processing machine;
Figure 2 is a plan view of the take-up and let-off mechanism shown in Figure 1;
Figure 3 is a front elevational view of the take-up and let-off mechanism illustrated in Figures 1 and 2;
Figure 4 is a cross-sectional view taken substantially along line 4—4 of Figure 1;
Figure 5 is a cross-sectional view taken substantially along line 5—5 of Figure 4; and
Figure 6 is a schematic view of the clutch and brake assembly of the take-up and let-off mechanism shown in Figures 1–3 and the control circuit therefor.

A constant tension take-up and let-off mechanism constructed in accordance with the present invention includes a reel which takes up wire from or feeds wire to a wire processing machine. The reel is connected to a shaft which is adjustable linked to the shaft of a motor through an eddy current operated coupling. The wire between the reel and the wire processing machine is arranged around a fixed and floating pulley so as to form one or more adjustable loops of wire. The coupling between the motor and the shaft which turns the reel is varied in response to the movement of the floating pulley so as to maintain the linear speed of the wire drawn from or into the processing machine equal to the peripheral speed of the winding diameter of the reel.

In operation, if the linear speed of the wire being drawn from or into the processing machine differs from the peripheral speed of the winding diameter of the reel, the adjustable loops of wire will shorten or lengthen which will raise or lower the floating pulley. This will cause a change in the coupling between the shafts which will decrease or increase the speed of rotation of the reel. The speed of the reel will be varied in this way.
until the linear speed of the wire being drawn from or to the processing machine equals the peripheral speed of the winding diameter of the reel, at which point the floating pulley will neither rise nor fall. Since there is always an adjustable loop between the take-up or let-off mechanism and the wire processing machine, the tension on the wire being drawn from or to the winding reel will remain constant.

Referring to Figure 1 of the drawings, reference numeral 10 indicates generally a truck or dolly suitably composed of angle irons and other structural members. The truck 10 is mounted for movement on a set of wheels 12 and is provided with a usual type stop 14 which may be adjusted vertically so as to frictionally contact the floor and thereby lock the truck in position. The truck 10 may also be provided with a guide bar 16 as illustrated in Figure 2 for moving the truck when the step 12 is raised.

The power for the various power operated elements on the truck 10 is supplied from a motor 18 (Figure 6) which connects to an input drive shaft 20. The drive shaft 20 is coupled to an output shaft 22 through an eddy current clutch and brake assembly 24. The motor 18 and clutch and brake assembly 24 are enclosed within a housing 26 mounted on the truck 10. The eddy current clutch and brake assembly 24 and the controls therefore will be set forth in greater particularity in succeeding descriptions of the mechanism. The output shaft 22 carries a sprocket wheel 28 about which a chain 30 is trained. The chain 30 in turn drives a sprocket wheel 32 which is keyed or otherwise secured to a shaft 34 which is supported on bearings 36 on the truck 10. One end of the shaft 34 extends beyond the edge of the truck 10 and connects with a wire take-up or let-off reel 38.

The reel 38 may include a portion 40 for the purpose of receiving scrap wire so as to separate such wire from the commercially useful wire which is wound on the main body of the reel 38.

Intermediate the ends of the shaft 34 is a V-belt pulley 42 about which a V-belt 44 is trained. The belt 44 drives a pulley 46 attached to one end of a shaft 48. Riding on the shaft 48 is a collar 50 associated with a follower 52 which forms part of a level winding mechanism for the tensioning device 22 engages a threaded shaft 54, the latter being driven from the shaft 48 by an adjustable speed reduction and reversing mechanism 56.

The direction of rotation of the shaft 54 is determined by the lateral position of a rod 60 which connects to a double bevel gear (not shown) of the speed reduction and reversing mechanism 56. An arm 58 of the follower 52 engages a groove in the collar 50 so as to position the outer end of the arm 58 above a threaded portion of the rod 60. When the shaft 54 is rotated, the arm 58 will move laterally until it comes into contact with one of a pair of stops 62 which are adjustable positioned on the threaded rod 60. Continued rotation of the shaft 54 will cause the rod 60 to move laterally, thus actuating the gear drive and reversing the direction of rotation of the shaft 54. Thus, as the shaft 54 rotates, the follower 52 will reciprocate therefore between limits which are determined by the stops 62.

The follower 52 is further provided with a pair of parallel arms 64 located directly opposite to the arm 58 which carry a rod 66. The rod 66 extends through a bearing 68 mounted on the truck 10 and has a level winding pulley 70 rotatably secured on the outer end thereof. The pulley 70, of course, reciprocates with the movement of the follower 52 and functions to wind the wire evenly along the width of the reel 38.

Although the take-up and let-off mechanism illustrated in the drawings may operate either as a take-up or let-off mechanism, we shall initially discuss the operation of the mechanism when it is operating to take up wire from a processing machine (not shown), for example, an extruder which applies a soft coating or jacket onto the wire. Wire W from the processing machine is first trained about a vertically fixed pulley 72 which is rotatable on a shaft 74 supported by a bearing 76 which is attached to the upper end of a pair of opposed angle irons 78 which are carried by and extend upwardly from the truck 10. The wire W then passes over a freely slidable or floating pulley 80 whose axis is vertically movable with respect to the shaft 74. Although the fixed pulley 72 is shown in Figure 3, containing three sheaves and the floating pulley 80, two sheaves thereby providing two complete loops of wire between the pulleys 72 and 80, it should be understood that the number of sheaves in the pulleys may be changed to provide a different number of loops of wire between the pulleys.

The wire W passes from the final sheave of the fixed pulley 72 over the level wind pulley 70 to the reel 38. When the wire passes from the final sheave of the pulley 72 to the scrap portion 49 of the reel 38, it may be guided thereto by a guide pulley 42 which is connected to the truck 10.

The floating pulley 80 is free to slide vertically within limits, with respect to the pulley 72. The manner of supporting the floating pulley 80 is best illustrated in Figures 4 and 5 of the drawings. Blocks or spacers 84 are attached to the inwardly positioned faces of the angle irons 78 so as to define a guideline 86. The pulley 80 is rotatable on a shaft 88 which connects with a block 90 which is freely slidable within the guideline 86. Stops or spacers 92 located within the guideline 86 define limits of the vertical movement of the block 90 within the guideline 86. The weight of the floating pulley 80 is partially counterbalanced by a suitable weight 94 which connects with an eyebolt 96 extending from the block 90. The counterbalancing weight 94 is connected to the eyebolt 96 through a chain belt 98 which extends over a sprocket wheel 100, the sprocket wheel 100 being attached to the shaft 102 which is rotatable in a bearing 104. The eyebolt 96 also supports a hanging weight 106 which contributes to the tension on the wire W. When the pulley 80 is in equilibrium the tension on the wire W will be approximately equal to the weight 106 plus the weight of the block 90 and pulley 80 minus the weight 94 divided by the number of wire strands between the fixed pulley 72 and floating pulley 80. The tension on the wire W can be changed by substituting other weights for the weights 94 and/or 106 or by changing the number of loops which extend between the pulleys 72 and 80. With this arrangement, a wire tension as low as one ounce can be readily obtained.

When the reel 38 is rotated by the operation of the motor 18, the floating pulley 80 will move upwardly if the wire W is drawn from the processing machine at a slower rate of speed than it is taken up by the reel 38 and will move downwardly if the wire W is drawn from the processing machine at a faster rate than it was taken up by the reel 38. This upward or downward movement of the floating pulley 80 will produce a change in the coupling between the drive shaft 20 and the output shaft 22 so as to cause the reel 38 to take up the wire W at the same rate of speed as it is drawn from the processing machine.

As the floating pulley 80 moves upwardly or downwardly relative to the pulley 72, the chain belt 98 turns the sprocket wheel 100 and connecting shaft 102. The rotation of the shaft 102 will change the setting of a potentiometer 108, the potentiometer being mounted on a bracket 110 which connects with the upright channel members 76 and connected to the shaft 102 through a coupling 112.

The potentiometer 108 is associated with an electronic control circuit 114 which is designed as will be more fully set forth below, to vary the energization of the eddy current clutch and brake assembly 24 which controls the coupling between the input shaft 20 which is rotated
by the motor 18 and the input shaft 22 which connects with the wire reel 38. The control circuit may be mounted on the truck 10 as shown in Figures 2 and 3. The eddy current clutch and brake assembly 24 and control circuit 114 thereafter is diagrammatically illustrated in Figure 6. The output shaft 22 has no mechanical connection with the drive shaft 20 of the motor 18. Torque is transferred from the shaft 20 to the shaft 22 by the magnetic attraction between a drum 116 which is attached to the drive shaft 20 and a drum 118 which is attached to the output shaft 22 when direct current is fed from the control circuit 114 through slip rings 122 on the output shaft 22 to the field coil 120. The point at which speed stability of the output shaft 22 is obtained depends on the speed of rotation of the drive shaft 20, the amount of excitation current in the field coil 120, and the torque demand of the load. Readjustment of the excitation current to the field coil 120 causes a change in speed of the output shaft 22. The system also includes an annular coil 124 which is anchored to a housing 126 which encloses the eddy current clutch and brake assembly 24, the coil 124 being located circumferentially of, but spaced from, the drum 118 of the output shaft 22. When the coil 124 is energized, a magnetic flux is set up which opposes the rotation of the drum 118. The potentiometer 108 and associated control circuit 114 are so designed that when the potentiometer 108 is set to one end of its range, there will be no current sent from the control circuit 114 to the field coil 120 of the magnetic clutch; and when the potentiometer 108 is set at the other end of its range, a given maximum current will be sent to the field coil 120. Thus, when the potentiometer 108 is set to one end of its range, there will be no coupling between the shafts 20 and 22, and consequently, the reel 38 will remain stationary. As the potentiometer setting is changed, current will be sent to the field coil 120 causing a coupling between the shafts 20 and 22 thereby causing the reel 38 to rotate. The further the potentiometer 108 is set toward the upper end of its range, the greater will be the current in the field coil 118 and the faster will be the rotation of the reel 38.

In operation, the weight 106 which is attached to the eyebolt 96 is chosen so as to produce a prerequisite tension on the wire when the processing machine is not operating, the floating pulley 80 is located adjacent the upper stop 92. The potentiometer 108 is adjusted so that when the floating pulley 80 is adjacent the upper stop 92, it is set at the end of its range which produces zero current in the field coil 120. When the processing machine is started, the wire therefrom will cause the floating pulley 80 to descend. As the pulley 80 descends, it will cause the chain 98 to rotate the sprocket wheel 100 which in turn will rotate the potentiometer 108. As the potentiometer setting changes, the control circuit 114 will feed current to the field coil thereby causing a magnetic coupling between the shafts 20 and 22, and the reel 38 will begin to rotate. The floating pulley 80 will continue to descend until the current in the field coil 120 is sufficient to produce a coupling between the shafts 20 and 22 such that the reel 38 takes up wire at the same rate of speed as the wire is being fed from the processing machine. Conversely, as the processing machine slows down, wire will begin to be wound upon the reel 38 at a faster rate of speed than the wire is being drawn from the processing machine. This will cause the floating pulley 80 to rise, thereby turning the potentiometer 108 in the direction which causes a reduction in the current to the field coil 120 and a flow of current in the position of said eddy current control circuit 114 being so arranged that the coil 124 becomes energized when the current in the field coil 120 is decreasing. The braking action caused by the current in the coil 124 together with the reduced current in the field coil 120 will produce an immediate slowing down of the reel speed so as to follow closely the reduction of speed of the processing machine. This reduction of reel speed will continue until the processing machine is shut down and the reel 38 is stationary.

Since the coupling between the shafts 20 and 22 is a function of the torque on the shaft 22 as well as the speed of rotation of the shaft 20 and the current in the field coil 120, the greater the wire tension, the slower will be the speed of rotation of the shaft 22 for a given field current. The Electronic control circuits which are adapted to regulate the currents in the field coil 120 and braking coil 124 of the magnetic clutch and brake assembly 24 in the manner outlined above are well known in the art, such control circuit being produced by the Dynamatic Corporation of Kenosha, Wisconsin.

The foregoing describes the apparatus in its operation as a take-up mechanism. The apparatus is also operable to let off or feed wire at constant tension to a processing machine. However, when the apparatus is employed as a let-off mechanism, it is necessary to reverse the connections between the control circuit 114 and the potentiometer 108 since the floating pulley 80 will rise instead of falling when the processing machine is off and at an upper position when the processing machine is operating at maximum speed. A reversing switch 120 is provided for reversing the connections on the potentiometer 108 in order to permit the apparatus to operate either as a take-up or as a let-off mechanism.

From the foregoing, it is apparent that the apparatus of the present invention provides a unit which is independent of the processing machine with which it cooperates. The take-up and let-off mechanism can be satisfactorily used to provide a constant tension on the wire of from about 1 ounce to a tension of greater than 5 pounds over a wide range of wire speeds.

Various other modifications and changes can be made in the above described mechanism without departing from the scope of the present invention.

I claim:
1. A constant tension take-up and let-off mechanism for wire comprising loop forming means arranged to receive said wire, said loop forming means including a floating pulley around which said wire may be trained, a reel arranged to receive said wire from or deliver said wire to said loop forming means, a shaft carrying said reel, an electric motor arranged to rotate said shaft, an electromagnetic clutch and an electromagnetic brake providing a coupling between said motor and said shaft, control means operable in response to the movement of said floating pulley to vary the magnetic flux in said electromagnetic clutch to thereby vary the speed of rotation of said shaft, and said control means being further operable during at least a portion of the time when the magnetic flux in said electromagnetic clutch is changing to energize said electromagnetic brake.

2. A constant tension take-up and let-off mechanism for wire comprising loop forming means arranged to receive said wire, said loop forming means including a floating pulley around which said wire may be trained, a reel arranged to receive said wire from or deliver said wire to said loop forming means, a shaft carrying said reel, an electric motor arranged to rotate said shaft, an eddy current clutch and an eddy current brake providing a coupling between said motor and said shaft, a potentiometer connected to said floating pulley in a manner such that the setting of said potentiometer is determined by the position of said floating pulley, a control circuit connected to said potentiometer and said eddy current clutch which is operable in response to changes in the setting of said potentiometer to vary the magnetic flux in said eddy current clutch and thereby vary the speed of rotation of said shaft, and said control circuit being further connected to said eddy current brake and op-
erable during at least a portion of the time when the magnetic flux in said eddy current clutch is changing to energize said eddy current brake.

3. A constant tension take-up and let-off mechanism for wire which comprises a frame, a rotatable pulley mounted on a stationary axis on said frame, a slidable pulley carried by said frame and arranged to be supported by strands of wire trained about said first named pulley, a weight attached to said slidable pulley for providing a predetermined tension on said strands of wire, an electric motor carried by said frame, a shaft driven by said motor, an eddy current clutch and an eddy current brake providing a coupling between said motor and said shaft, a reel carried by said shaft for receiving said wire from or delivering said wire to said pulleys, a rotatable sprocket wheel carried by said frame, a chain secured at one end to said slidable pulley and trained over said sprocket wheel, a counterbalancing weight carried at the other end of said chain, a potentiometer mechanically coupled to said sprocket wheel in a manner such that the setting of said potentiometer is determined by the position of said sprocket wheel, and control means connected to said potentiometer, said eddy current clutch, and said eddy current brake and operable in response to changes in setting of said potentiometer to vary the magnetic flux in said eddy current clutch and said eddy current brake and thereby vary the speed of rotation of said shaft.

4. A constant tension take-up and let-off mechanism for wire which comprises a frame, a rotatable pulley mounted on a stationary axis on said frame, a slidable pulley carried by said frame and arranged to be supported by strands of wire trained about said first named pulley, a weight attached to said slidable pulley for providing a predetermined tension on said strands of wire, an electric motor carried by said frame, a shaft driven by said motor, an eddy current clutch and an eddy current brake providing a coupling between said motor and said shaft, a reel carried by said shaft for receiving said wire from or delivering said wire to said pulleys, a rotatable sprocket wheel carried by said frame, a chain secured at one end to said slidable pulley and trained over said sprocket wheel, a counterbalancing weight carried at the other end of said chain, a potentiometer mechanically coupled to said sprocket wheel in a manner such that the setting of said potentiometer is determined by the position of said sprocket wheel, a control circuit connected to said potentiometer and said eddy current clutch which is operable in response to changes in the setting of said potentiometer to vary the magnetic flux in said eddy current clutch and thereby vary the speed of rotation of said shaft, said control circuit being further connected to said eddy current brake and operable during at least a portion of the time when the magnetic flux in said eddy current clutch is changing to energize said eddy current brake and thereby vary the speed of rotation of said shaft, and level wind means attached to said frame and operable controlled by the rotation of said shaft for guiding said wire to said reel.

5. A constant tension take-up and let-off mechanism for wire which comprises a frame, a rotatable pulley mounted on a stationary axis on said frame, a slidable pulley carried by said frame and arranged to be supported by strands of wire trained about said first named pulley, a weight attached to said slidable pulley for providing a predetermined tension on said strands of wire, an electric motor carried by said frame, a shaft driven by said motor, an eddy current clutch and an eddy current brake providing a coupling between said motor and said shaft, a reel carried by said shaft for receiving said wire from or delivering said wire to said pulleys, a rotatable sprocket wheel carried by said frame, a chain secured at one end to said slidable pulley and trained over said sprocket wheel, a counterbalancing weight carried at the other end of said chain, a potentiometer mechanically coupled to said sprocket wheel in a manner such that the setting of said potentiometer is determined by the position of said sprocket wheel, a control circuit connected to said potentiometer and said eddy current clutch which is operable in response to changes in the setting of said potentiometer to vary the magnetic flux in said eddy current clutch and thereby vary the speed of rotation of said shaft, said control circuit being further connected to said eddy current brake and operable during at least a portion of the time when the magnetic flux in said eddy current clutch is changing to energize said eddy current brake, level wind means attached to said frame and operably controlled by the rotation of said shaft for guiding said wire to said reel and switch means for varying the connections between said potentiometer and said control circuit to set the mechanism for operation either as a take-up mechanism or as a let-off mechanism.

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