

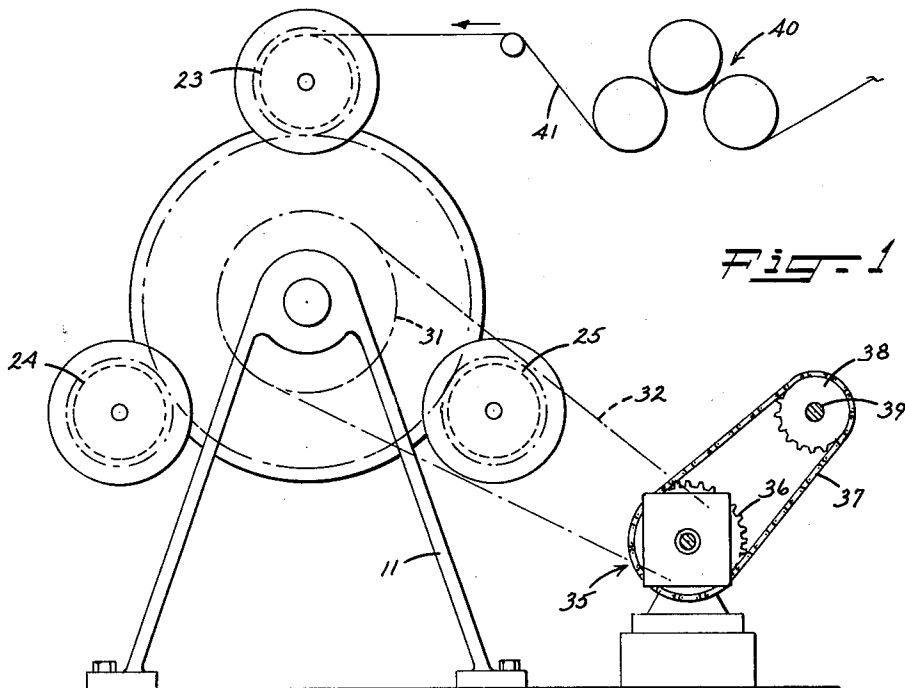
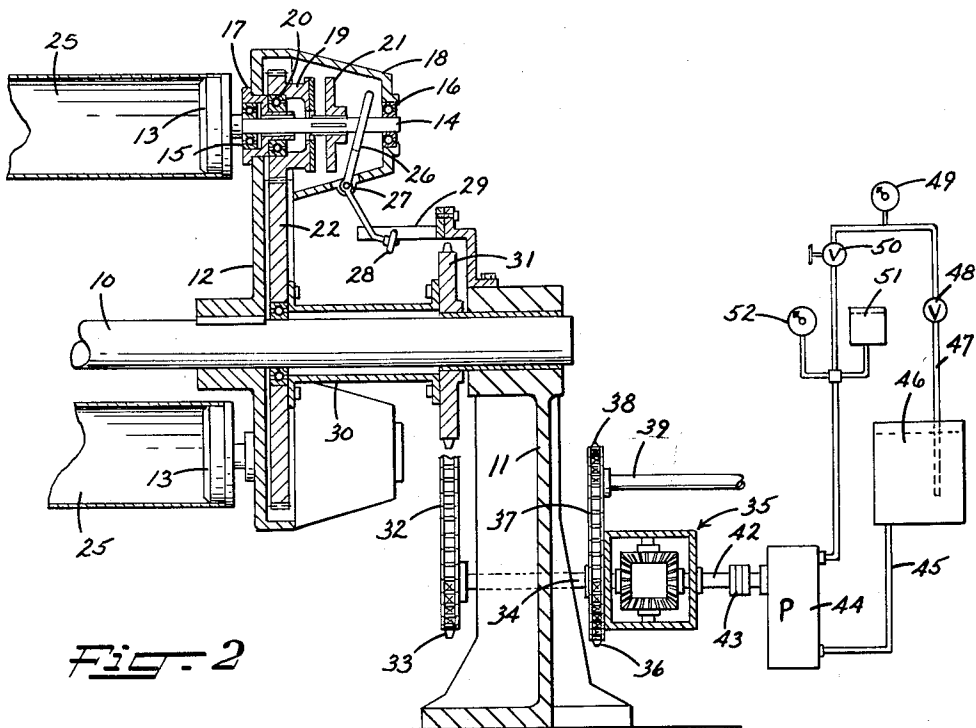
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DIFFERENTIAL WIND-UP APPARATUS

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DIFFERENTIAL WIND-UP APPARATUS

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This invention relates to apparatus for winding films, webs and strands which are being fed at a substantially steady rate to a winding drum, core, reel or the like. More especially the invention deals with apparatus for controlling the tension in the material being wound and in its more particular aspects provides an improved means for continuously reducing the tension during the winding operation.

In the art of winding sheet material into rolls it is recognized as desirable that the tension on the material be reduced as the diameter of the roll increases. Generally some operation is being performed on the sheet prior to the winding into roll form. For example, the sheet may be coated, printed, impregnated or even manufactured just prior to being wound and during these operations it is usually desirable to maintain a constant tension, but smoother, more even winding may be effected if, during winding, the tension is gradually reduced as the roll diameter increases. This reduction in tension is known as tension taper and the most desirable taper depends to a large extent upon the nature of the material being wound and is determined empirically to produce a roll wherein the sheet is smooth and unbuckled. Tension taper is also important in the winding of strand material, particularly strand material which is stretched to a certain extent during winding, and while the invention will be described in connection with the winding of a relatively wide sheet or film it is to be understood that the term "sheet" is employed to connote any flexible member which is many times longer than its width and thickness and may encompass what is normally called a strand.

For certain winding operations a satisfactory tension taper may be provided by applying a constant torque to the winding roll. Since the torque is equal to the tension on the sheet multiplied by the radius of the roll, constant torque winding produces a rather steep tension taper which in most practical cases provides too little tension at the end. While the art of winding is old and rather well developed, heretofore known arrangements for controlling tension have not been entirely satisfactory. In general it can be said that the prior art devices are either very complicated, expensive and difficult to maintain in proper adjustment or are lacking in accuracy and reliability.

It is an object of the present invention to provide a winding apparatus which is relatively simple in construction, reliable in operation and which may be readily adjusted to provide any desired degree of tension taper.

Other and further objects, features and advantages of the invention will become apparent as the description of certain preferred embodiments thereof proceeds.

Referring now to the drawings:

FIGURE 1 is a diagrammatic side elevational view of the apparatus; and

FIGURE 2 is a view partially diagrammatic and partially in section of the apparatus, the winding cores being shown in a different position than in FIGURE 1.

While the invention will be described in connection with the continuous winding of flexible films and while some of its outstanding advantages are most fully realized in this connection, it will be apparent that it has application in a variety of other winding and re-winding operations.

The winding mechanism itself comprises a turret including a shaft 10 rotatably mounted at opposite ends

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in supports 11, only one of which is shown. The shaft 10 has keyed thereto a spider 12 on which are rotatably mounted a plurality, three in the present instance, of roll core driving and supporting heads 13. Each head 13 is secured to a shaft 14 mounted in bearings 15 and 16 carried respectively by a sleeve insert 17 of the spider 12 and a cap 18 secured to the spider. The cap 18 is removably secured to the spider, by means not shown, to permit access to a clutch comprising a driving member 19 rotatable on a bearing 20 carried by the sleeve insert 17 and a driven member 21 splined on the shaft 14. The driving clutch member 19 includes a pinion, the teeth of which are engaged with a continuously rotating gear 22 journaled on the shaft 10.

In FIGURE 1 the uppermost roll core 23 is shown in active winding position and the winding operation is underway, while cores 24 and 25 are in inactive position. In FIGURE 2, the winding of core 23 has been completed and it has been moved to position for removal from the winding apparatus and is not shown. In this latter figure the core 25 is just about to reach the active winding position. This movement of the cores to and from the winding position is accomplished by rotating the shaft 10 through an arc of 120° by means not a part of the present invention and not shown. As a core reaches the active winding position, the driven clutch member 21 is moved against the driving member 19 to couple the rotating gear 22 with the shaft 14 and thus effect a driving connection from said gear to the roll core. The movement of the clutch member 21 is effected by a shifter lever 26 intermediately pivotally mounted on the cap 18 at 27 and having a clutch member engaging yoke at one end and an operating roller 28 at the other. The roller 28 engages a cam 29 mounted on the support 11 when the roll core is in winding position to hold the clutch engaged and moves off the cam when the spider is turned so as to permit disengagement of the clutch.

For rotating the gear 22, a sleeve 30 is connected at one end to said gear and at its other end is connected to a sprocket 31 journaled on the shaft 10. A chain 32 connects the sprocket 31 to a sprocket 33 secured to one output shaft 34 of a differential drive generally designated at 35. The differential may be of the same type as commonly used in rear wheel drive automobiles and is driven through the housing or cage gear 36 which is connected by a drive chain 37 to a pulley, gear or sprocket 38 secured to a constant speed shaft 39. Preferably, for a reason presently to be explained, the shaft 39 also drives the machine which manufactures or otherwise processes the film and in the present instance said shaft drives the rolls 40 which are feeding the film 41 at a constant linear speed toward the winding mechanism, as shown in FIGURE 1. The three rolls 40 are merely intended to indicate the last of what is normally a long series.

It has previously been mentioned that the present invention provides a system for controlling the rate of taper of the film tension as the size of the winding roll increases. The means for effecting this control will now be described but first it should be mentioned that the invention makes use of certain well-known basic scientific principles and phenomena. The first of these is that in a differential gearing, when power is applied to the case gear, the torque is always identical on the two output shafts, regardless of any speed differences between them. From this it follows that by controlling the torque of one of the output shafts, the torque of the other is automatically accomplished.

Since the differential output shaft 34 is used to drive the winding roll, the other output shaft, indicated at 42, is used as the control. Shaft 42 is connected by a coupling 43 to a positive displacement pump 44 which conveniently may be a gear pump. A line 45 extends from

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an oil reservoir 46 to the inlet of the pump and a line 47 feeding back into the reservoir is connected to the pump outlet. In that form of the invention shown in FIGURE 2, a manually adjustable constant pressure valve 48 is located in the line 47 and a gauge 49 indicates the pressure upstream from said valve. Constant pressure valves of this type are readily available from a number of sources and when and if the pressure in line 47 between the valve and the pump falls below the setting of the valve, said valve closes completely. Also located in the return line 47 between the pump and valve 48 is an adjustable orifice or valve 50. While the function of orifice 50 will be later alluded to, it is believed that the operation of the system can best be explained by first considering the case with said orifice fully opened or entirely out of the system. Under this circumstance, constant pressure valve 48 provides a constant back pressure in the line 47 and on the pump 44.

The operation of the system will now be explained. Assume the condition wherein a roll has just been completed and a new core moved into winding position. At that instant there is very little load or torque on the output shaft 34 and consequently a similar low torque on output shaft 42, this being the nature of a differential as mentioned above. This low torque on shaft 42 is insufficient to operate positive displacement pump 44 against the pressure in line 47. That is to say there is not enough torque applied to the pump to cause the valve 48 to open and permit a flow of oil through the line 47, valve 48 being set at a pressure such that this condition prevails. Since the pump 44 is not operating, the output shaft 42 of the differential does not turn and the output shaft 34 accordingly turns at its full speed which is exactly twice the speed of case gear 36. From FIGURE 1 it will be apparent that when the new core is in position of core 23, the previously wound core will be in the position of core 24 and the film therefore extends partially around the periphery of core 23 as it moves onto the roll which is now in the core 24 position and which incidentally is still rotating under its own momentum, although disconnected from the source of power. An operator then cuts the film between core 23 and the full roll and quickly wraps the then leading end about core 23 whereupon the film begins to wind on core 23. The drive ratio between differential output shaft 34 and core rotating shaft 14 is such that with shaft 34 turning at full roll speed, the core is rotated at a peripheral speed from 2 to 5% faster than the linear speed of the film, the linear speed being determined by rolls 40. It is this higher speed of core 23 which enables the operator to attach the film to the core merely by wrapping it around the core so that the leading edge passes between the oncoming film and the core.

Immediately upon the film becoming attached to the new winding core a relatively high tension is induced into the film because the core is attempting to wind it faster than it is being supplied by rolls 40. This high tension of course produces a high torque on the output shaft 34 of the transmission. The torque supplied to the output shaft 42 is correspondingly high and of a magnitude sufficient to overcome the back pressure applied to pump 44. This instantly raises the pressure in the oil return line 47 and to avoid a pressure shock on the automatic valve 48 a pressure dampener 51 is provided in line 47 between said valve and the pump. This dampener is a closed container partially filled with oil from line 47 and having an air pocket above the oil level. Thus while the differential output shaft 42 and the pump 44 start to turn instantly upon attachment of the film to the roll core, the pressure in line 47 is momentarily applied to compressing the air in dampener 51. This gives the automatic valve a chance to open and permit oil to flow back into the reservoir at the preselected pressure.

The main part of the winding operation has now begun and both output shafts of the differential 35 are turning. 75

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The torque on roll driving shaft 14 is determined by the tension on the film multiplied by the radius of the roll. This produces a certain torque on differential output shaft 34, the value of which can be calculated by multiplying the torque on shaft 14 by a constant determined by the drive ratio between shafts 34 and 14. It is again noted that the torque on output shaft 42 must be identical with the torque on shaft 34. Now the torque on shaft 42 depends entirely upon the pressure in line 47, that is to say, upon the back pressure on pump 44. Thus by setting the constant pressure valve 48 so as to provide a particular torque on shaft 42, any desired tension on the film at the starting radius can be effected. Since the valve 48 is a constant pressure valve, the torque on shaft 42 will be the same regardless of the amount of oil flowing, or the speed of the shaft. Since the torque on shaft 42 is maintained constant, the torque on shaft 34, and on shaft 14 to which it is drivingly connected, remains constant throughout the winding operation. Thus as the size of the roll of film increases, the tension on the film decreases in direct proportion since the torque on drive shaft 14 is equal to the radius of the roll multiplied by the tension on the film. In order for the tension to decrease, the roll speed and speed of the drive shaft 14 must decrease and the differential drive permits this to take place. As the output shaft 34 slows down, the output shaft 42 of course speeds up so that the sum of the output shaft rotating speeds remains constant and the pump 44 pumps more oil through the line 47, but the pressure in line 47 remains the same because of the constant pressure valve 48. When the roll reaches the desired diameter, the clutch 19, 21 disengages as the roll is moved out of winding position and the torque on shaft 34 and likewise on shaft 42 is reduced below the value necessary to maintain the flow of oil through the constant pressure valve 48. The valve then closes and the pump 44 stops, as does the output shaft 42. This immediately causes the shaft 34 to turn at full speed so that when the new core reaches winding position it is brought to full speed without delay. This fast action constitutes one of the big advantages of the invention.

For many winding operations the tension taper or decrease in film tension as the diameter of the winding roll increases, which is produced by the above-described constant torque winding, is eminently satisfactory. However, depending somewhat upon the nature of the material being wound, it is often desirable to provide a package or roll wherein the tension tapers to a lesser degree and it is for this reason that the above-mentioned adjustable orifice 50 is provided. It has been previously noted that the present invention makes use of several basic principles or phenomena and two of these will be mentioned in order to explain the function of orifice 50. First, the film tension at any given roll diameter is directly proportional to the torque applied to the roll drive shaft. Thus in the present instance the tension is directly proportional to the torque applied to pump 44 since the torque of roll drive shaft 14 when multiplied by the constant determined by the gearing ratio between shaft 14 and shaft 34 is identical to the torque applied to pump drive shaft 42. Furthermore, since the torque applied to shaft 42 is directly dependent upon the pressure at the discharge of the pump, the tension in the film is directly related to the pressure in oil line 47 at the pump discharge. Second, the pressure drop in a liquid flowing through an orifice varies with the square of the flow rate and with the same flow rate, the magnitude of pressure drop can be adjusted by increasing or decreasing the size of the orifice.

Now, suppose the orifice 50 is adjusted so that at the beginning of the winding operation when there is very little flow through the line 47 the pressure upstream from the orifice which, incidentally, may be read on a gauge 52 provided for that purpose, is just slightly higher than the pressure indicated on the gauge 49, this latter pres-

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sure being the constant pressure provided by valve 48. It is the pressure shown by gauge 52, i.e. the sum of pressure drops due to constant pressure valve 48 and adjustable orifice 50 that the pump 44 is working against and this is the pressure that determines the winding torque and the tension on the film. As the winding roll increases in diameter the pump speed must increase and pump a constantly increasing amount of oil through line 47. Because of orifice 50, this will result in a constantly increasing pressure at the discharge of pump 44 which of course means a constantly increasing torque on roll drive shaft 14, as explained above. Thus the tension in the film will not taper as rapidly as in the case where orifice 50 is omitted. By regulating the opening of orifice 50, whatever tension taper is desired may be obtained.

In the foregoing embodiment of the invention the tension in the film is unaffected by variations in the delivery speed of feed rolls 40, whether the speed change is deliberate and prolonged or accidental and momentary, since the case gear 36 of the differential is tied in with the feed rolls through the common drive shaft 39.

Having thus described certain preferred embodiments of the invention, what is claimed is:

1. Winding apparatus comprising a core on which sheet material is wound into a roll, means for feeding sheet material toward said core at a constant linear speed, a

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differential comprising a power input and two outputs, means for driving said input at a constant speed, means drivingly connecting one of said outputs to said core, a positive displacement pump means operatively connected to the other of said outputs, means for supplying a liquid to said pump means, a conduit connected to said pump means for conveying liquid from said pump means, a constant pressure valve in said conduit, and an orifice in said conduit between said constant pressure valve and said pump means, said orifice being effective to continuously increase the back pressure on said pump means during the entire winding operation.

2. The apparatus set forth in claim 1 wherein the means for driving said input is interconnected with the means for feeding sheet material.

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