Feb. 22, 1949. J. W. OLSON ET AL 2,462,766

TENSION CONTROL APPARATUS

Filed May 9, 1946 2 Sheets-Sheet 1

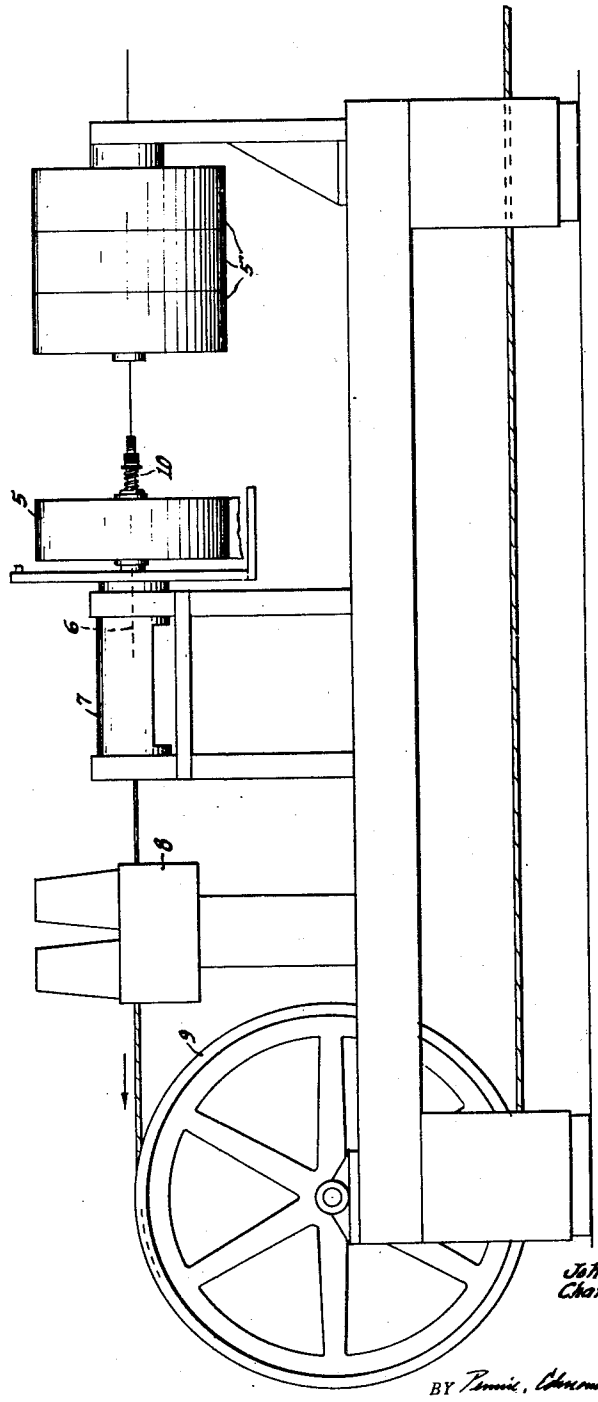


Fig. 1

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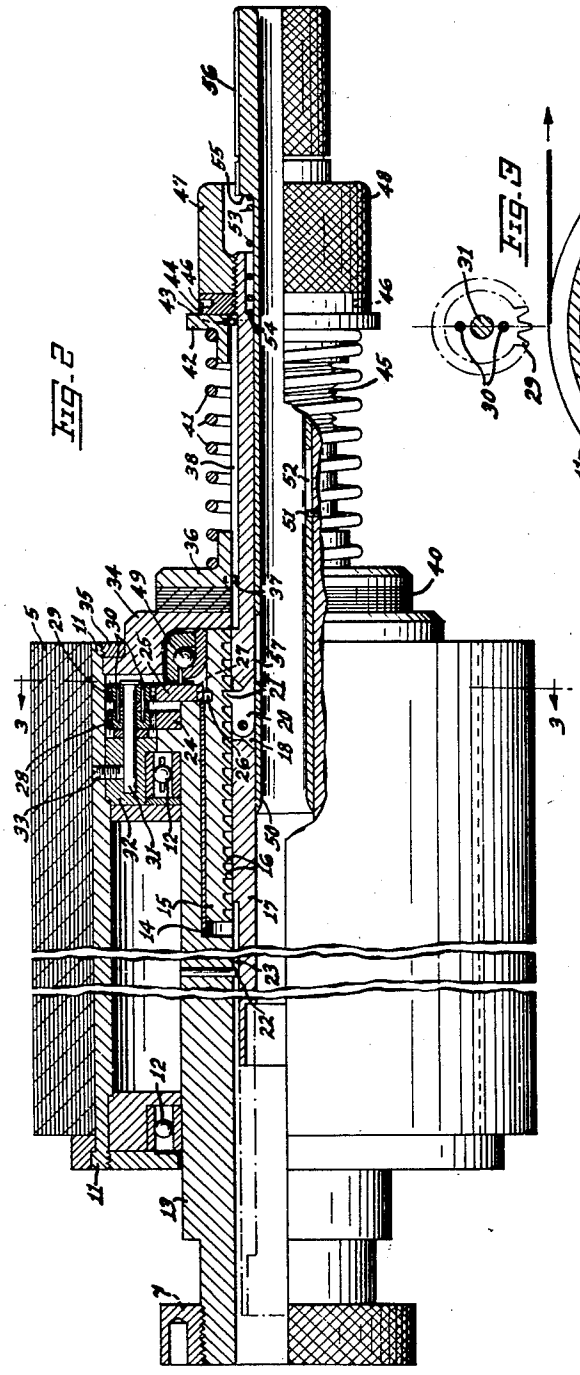


FIG. 2

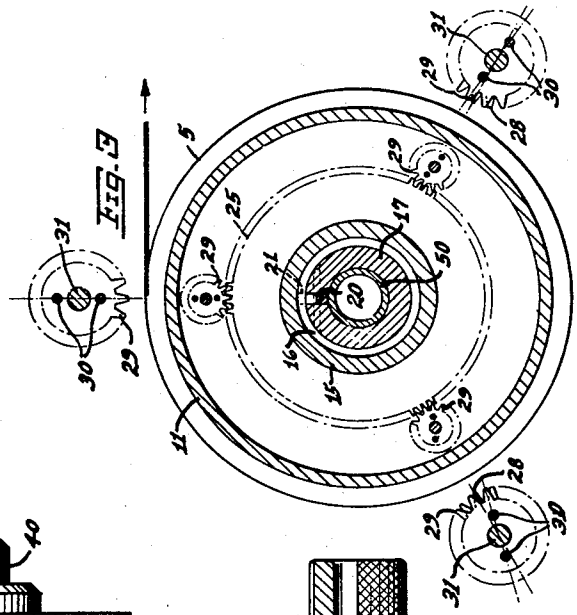


FIG. 3

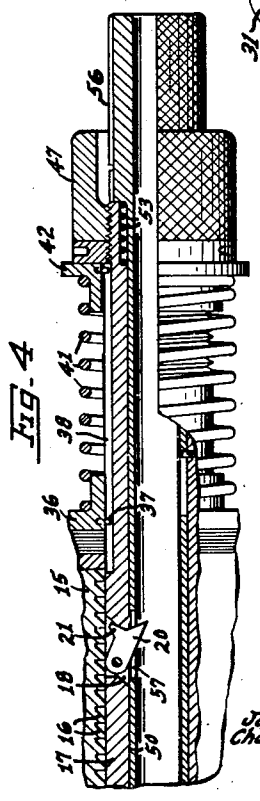


FIG. 4

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TENSION CONTROL APPARATUS

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Application May 9, 1946, Serial No. 668,593

4 Claims. (Cl. 242—75)

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This invention relates to tension control apparatus and, more particularly, to apparatus adapted to provide substantially constant tension on material being unwound from a roll. The invention contemplates tension control apparatus wherein the tension is controlled in response to the amount of rotation of a body of material being unwound.

In many operations where material is wound on a base element it is important that the material be applied to the base element under uniform tension. Inasmuch as the material used in such operations is generally supplied in the form of a roll of the material, it becomes necessary to provide uniform or constant tension on the material as it is being unwound from the roll. It is a simple matter to provide resistance to unwinding of the roll, but it is difficult to control this resistance in such manner as to insure substantially constant tension on the material throughout the unwinding of the entire roll. As material is pulled from a roll, the leverage of this pull is greatest when the roll diameter is greatest and decreases as the roll diameter decreases. Thus, if the roll is provided with a constant resistance to rotation, the amount of pull (tension) required to unwind the roll is least when the roll diameter is greatest and the required amount of pull increases as the diameter of the roll decreases during unwinding. Accordingly, some provision must be made for decreasing the amount of resistance to rotation of the roll during unwinding if a reasonably uniform tension is to be maintained on the material as it is unwound.

Numerous devices have been proposed and used heretofore for the purpose of controlling the tension on material being unwound from a roll. Such devices for the most part have been of two general types, one where the tension control is made responsive to the changing peripheral speed of the roll and the other where the tension control is made responsive to the changing diameter of the roll. The speed- or diameter-responsive element generally comprises a rider bearing against the periphery of the roll and has been characterized by erratic results. Tension variations as high as 25% or more must often be tolerated with such devices. Furthermore, in the many instances where the roll of material itself must be rotated about the base element, as in winding paper tape about a wire for example, centrifugal force acting on the rider has tended further to affect adversely the accuracy of its response and control.

The apparatus of the present invention comprises a marked improvement over the tension

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control devices of the prior art by providing tension control responsive to the amount of rotation of the roll of material. The apparatus is adapted to provide substantially constant tension on material as it is unwound from a roll, although it can also be used to provide increasing or decreasing tension at any desired rate as the material is unwound. The apparatus of the invention comprises a roll carrier rotatably mounted on a support, friction means adapted to provide frictional resistance to rotation of the roll carrier with respect to the support, and mechanical means interconnecting the roll carrier and the support arranged to control the amount of said frictional resistance in proportion to the extent the roll carrier rotates relative to the support in the direction corresponding to unwinding of material from the roll. The mechanical means interconnecting the roll carrier and the support is particularly arranged to decrease the frictional resistance to rotation of the roll carrier in proportion to the extent the roll carrier rotates relative to its support, and in this manner the apparatus is capable of providing substantially constant tension on the material as it is unwound from the beginning to the end of the roll. This mechanical means advantageously comprises, in accordance with the invention, an epicyclic gear train having first and second main gears provided with different numbers of teeth. The first main gear is mounted in fixed position on the roll carrier support and the second main gear is mounted for rotation about the axis of said support. The main gears are interconnected by an idler gear assembly mounted on the roll carrier. Rotation of the roll carrier effects rotation of the idler gear assembly around the main gears with resulting rotation of the rotatably mounted second main gear with respect to the fixed main gear. Means are provided for varying the frictional resistance in the friction means in responsive to rotation of the rotatable main gear with respect to the fixed main gear as the roll carrier rotates with respect to its support. The frictional resistance in the frictien means is controlled in accordance with the invention by compression of a spring mounted coaxially with the roll carrier support, and means are provided to translate rotation of the rotatable main gear of the epicyclic gear train into motion along the axis of the support whereby compression of the spring is varied in proportion to the extent the roll carrier rotates relative to its support in the direction corresponding to unwinding of the material from the roll.

These and other novel features of the invention

will be more fully understood from the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows apparatus for covering wire wherein the wire is covered with material unwound from a roll with tension on the material controlled by apparatus embodying the invention;

Fig. 2 is a detailed view partly in section of the constant tension apparatus of the present invention;

Fig. 3 is a sectional view taken along section line 3—3 in Fig. 2; and

Fig. 4 is a detailed sectional view of a portion of the constant tension apparatus shown in Fig. 2.

Although the apparatus of the invention will be described herein in conjunction with its use in maintaining constant tension on tape being applied to an electric conductor, it will be appreciated from the following description of the apparatus that it is equally applicable to the unwinding of any material, whether in sheet or filament form. The constant tension apparatus is shown in Fig. 1 in use with wire covering apparatus wherein paper tape from a roll 5 is applied to and wound about a wire 6 by a paper applicator 7. The wire with its covering of paper is passed through a jacketing section 8 wherein a fibrous jacket ie applied about the paper covering on the wire. The wire is drawn through these operations by means of a capstan 9 from which the covered wire may be delivered to any subsequent operation such as that in which it is impregnated with asphalt, or the like. The constant tension apparatus 10 of the present invention is used to maintain a substantially constant tension on the paper tape being unwound from the roll 5 and applied to the wire by the applicator 7. It will be appreciated from Fig. 1 that this constant tensioning apparatus must be such that the same amount of tension may be maintained on other spare rolls of tape 5' when these rolls are moved from their magazine into unwinding position when the starting roll 5 has been completely unwound.

The apparatus of the invention, as shown in detail in Fig. 2, comprises a cylindrical roll carrier 11 rotatably mounted by means of ball bearings 12 on a support 13. The support 13 is adapted to be secured to the end of the paper applicator 7. The roll carrier support 13 comprises a hollow cylinder having the interior of one end portion cut away to provide a recess 14. Mounted within this recess is a cylindrical shell 15 threaded internally with buttress threads 16. Mounted within the interior of the cylindrical support 13 and the threaded surface of the cylindrical shell 15 is an elongated tube 17 which extends rearwardly and outwardly beyond the end of the support 13.

The tube 17 comprises the tension controlling member of the apparatus, that is, movement of the tube 17 longitudinally along the axis of the support 13 is utilized to control the frictional resistance to rotation of the roll carrier 11 with respect to its support 13. This longitudinal movement is provided by translating rotation of the threaded shell 15 into longitudinal movement of the tube 17. The desired translation is obtained by providing the wall of the tube 17 with an opening 18 in which a pawl 20 is pivoted. The pawl is provided with a tooth 21 adapted to engage the buttress threads 16 of the shell 15. The tube 17 is keyed to the roll carrier support 13 by means of a pin 22 mounted in the support and extending into a keyway 23 cut into the outer surface of

the innermost end of the tube 17. Thus, the tube 17 is non-rotatably keyed to the support 13 but is free to move longitudinally along the axis of the support as its toothed pawl 20 is moved (to the left or right as viewed in Fig. 2) in response to rotation of the shell 15 with respect to the support 13.

Rotation of the threaded shell 15 with respect to the support 13 is provided advantageously in a specific embodiment of the invention by a reduction gear assembly in the form of an epicyclic gear train. The gear train comprises two main gears and an idler or spur gear assembly. One of the main gears 24 is mounted in fixed position on the roll carrier support 13. The other main gear 25 is mounted on the threaded shell 15 by means of a pin 26 set into the outer surface of the shell 15 and extending into a keyway 27 in the main gear 25. The two main gears, one mounted on the support 13 and the other mounted on the threaded shell 15, are provided with different numbers of teeth. In a specific embodiment of the invention the main gear 24 mounted on the support 13 is provided with ninety-nine teeth and the other main gear 25 mounted on the shell 15 is provided with one hundred teeth. The actual number of teeth or the difference in number of teeth in the two main gears is not critical, the important consideration being that the gear train provide the correct amount of movement of the shell 15 for a given amount of rotation of the roll carrier about its support in order to provide the desired change of frictional resistance to rotation of the roll carrier. The two main gears 24 and 25 are interconnected by an idler gear assembly comprising two spur gears 28 and 29 locked together by pins 30 extending through both spur gears. Actually, three of these idler gear assemblies are provided at spaced intervals around the main gear in order to insure dynamic balance and additional support for the internal parts of the apparatus. Both of the spur gears 28 and 29 of each assembly are provided with the same number of teeth and the two gears are mounted as an assembly on a shaft 31 mounted in an annular bearing housing 32 secured to the roll carrier 11 by means of screws 33, or the like. As the spur gears are carried around the main gears by rotation of the roll carrier 11, one of the spur gears 28 walks around the main gear 24 mounted on the roll carrier support 13 and the other spur gear 29 walks around the other main gear 25 mounted on the threaded shell 15. Inasmuch as the two main gears have a net difference of one tooth, the three sets of interconnected spur gears must compensate for this difference. Thus, with the teeth of one of the pairs of spur gears aligned (as shown in the enlarged view above the top of Fig. 3), the next pair of spur gears in the direction of rotation must have gear 29 advanced one-third of a tooth beyond gear 28 (as seen at the four o'clock position in Fig. 3) and the third pair of spur gears must have gear 29 advanced two-thirds of a tooth beyond gear 28 (as shown at the eight o'clock position in Fig. 3). In one complete revolution of the roll carrier 11, the two spur gears of any pair will walk around ninety-nine teeth comprising the periphery of the fixed main gear 24. But inasmuch as the other main gear 25 has one hundred teeth of which only ninety-nine will be traversed when the spur gears have been carried around by one complete revolution of the roll carrier, this main gear 25 is carried around by the interconnected spur gears a distance of the one remaining tooth

in the same direction of rotation as the direction of rotation of the roll carrier 11. It will be seen, therefore, that one hundred revolutions of the roll carrier 11 will cause the main gear 25 to make one complete revolution relative to the other main gear 24. This rotation of the main gear 25 mounted on the threaded shell 15 effects rotation of the shell with respect to its relatively stationary support 13 bearing the fixed main gear 24. Rotation of the shell 15 is translated as already described into longitudinal movement of the tube 17 along the axis of the support 13. If the buttress threads 16 on the interior of the rotatable shell 15 are right-hand threads, rotation of the roll carrier 11 in the direction indicated in Fig. 3 as paper is unwound from the roll 5 will cause the tube 17 to move to the right in Fig. 2. Movement of the tube 17 in this direction serves to decrease the frictional resistance to rotation of the roll carrier 11 with respect to its support 13.

The frictional resistance to rotation of the roll carrier 11 with respect to its support 13 is provided by the friction means shown at the right end of the roll carrier 11 in Fig. 2. The friction means comprises an annular ring 34 secured to the roll carrier 11 by means of a retaining ring 35. An annular collar 36 is mounted on an intermediate portion of the tube 17 and is keyed to the tube by means of a pin 37 projecting into a keyway 38 cut into the exterior surface of the end portion of the tube 17. The annular collar 36 is thus non-rotatably secured to the tube 17 and is adapted to remain in substantially fixed position when the tube 17 is moved longitudinally along its axis. A friction element 40, such as a leather washer or the like, is mounted between the annular ring 34 and the annular collar 36. The friction element may be secured to the face of either the annular ring 34 or the annular collar 36 or it may be mounted freely between them and secured to neither. It will be seen that the annular ring 34 is secured to the roll carrier 11 and rotates with the roll carrier whereas the annular collar 36 is non-rotatably keyed to the tube 17 which itself is non-rotatably keyed to the relatively stationary roll carrier support 13. Thus, the annular collar 36 remains stationary with respect to the support 13 whereas the annular ring 34 rotates with the roll carrier 11.

The amount of frictional resistance to relative rotation between the annular ring 34 and the annular collar 36 (and hence the frictional resistance to rotation of the roll carrier 11 with respect to its support 13) is a function of the compression of a coil spring 41 held in compression between the annular collar 36 and a retaining collar 42. This retaining collar 42 is mounted adjacent the end portion of the tube 17 and is keyed to the tube by a pin 43 extending into the keyway 38. The retaining collar 42 may be moved longitudinally toward or away from the annular collar 36 in order to adjust the spring pressure on the collar 36 by means of an adjusting nut 44. The nut 44 engages the threads 45 provided on the extreme end portion of the tube 17 and is provided with spanner wrench holes 46 to facilitate this adjustment. Once the adjustment is made, it is held by means of a locknut 47 provided with a knurled surface 48 so that it may be tightened readily by hand. The pressure of the spring 41 against the roll carrier assembly is taken up by a thrust bearing 49.

As previously described, the tube 17 moves outwardly (to the right as seen in Fig. 2) as the paper is unwound from the roll 5, thus progressively decreasing the compression of the spring 41 and hence decreasing the frictional resistance to rotation of the roll carrier 11 with respect to its support 13. When the roll of paper is completely unwound, the tube 17 will be moved to its extreme outward position (to the right) so that the toothed pawl 20 engages the outermost end of the buttress threads of the shell 15. When a new roll of paper is again mounted on the roll carrier 11, it is necessary to return the tube 17 with its toothed pawl 20 to the extreme innermost position (to the left as seen in Fig. 2) to provide the greatest amount of frictional resistance to rotation of the roll carrier 11. This movement is made possible by a cylindrical guide member 50 in the form of a tube adapted to fit within the interior of the tension control tube 17. The tubular guide member 50 is keyed to the tube 17 by means of a screw pin 51 projecting through the tube 17 into a slot 52 formed in the wall of the guide member 50. The pin 51 engaging the slot 52 permits restricted longitudinal movement of the guide member within the tube 17. The guide member is held in its outermost longitudinal position (to the right as seen in Fig. 2) with respect to the tube 17 by means of a coil spring 53. This spring is held between a shoulder 54 provided by an annular inner recess formed in the outer end of the tube 17 and a shoulder 55 formed by a knurled knob 56 provided on the outer end of the guide member 50. By pushing inward (to the left) on the knurled knob 56 against the compression spring 53, another slot 57 provided in the wall of the tubular guide member 50 is moved under the pivoted pawl 20. The pawl is thus permitted to drop down into the slot 57 so as to release its tooth 21 from engagement with the buttress threads 16 of the rotatable shell 15. With the pawl now out of engagement with the shell 15, the knurled locknut 47 may be pushed inwardly to force the tube 17 inwardly (to the left as seen in Fig. 2) through the shell 15. Then, with the tube 17 advanced as far inwardly as is permitted by the pin 22 extending into the keyway 23, the knurled knob 56 on the end of the guide member 50 is released. As the guide member is forced outwardly (to the right as seen in Fig. 2) by the spring 53, the slot 57 is moved longitudinally away from under the pawl 20 so that it is forced upwardly by the wall of the tubular guide member 50 into engagement with the buttress threads 16 adjacent the innermost end of the shell 15 (the left end as seen in Fig. 2). The frictional resistance to rotation of the roll carrier 11 with respect to its support 13 is once again returned to its maximum value and will decrease in proportion to the amount of rotation of the roll carrier as the paper is unwound from the new roll.

It will be seen that the apparatus of the present invention provides means for decreasing the frictional resistance to rotation of a roll carrier with respect to its support substantially proportional to the amount of rotation of the roll carrier with respect to its support, whereby substantially constant tension is maintained on the material. The apparatus is also characterized by the fact that once the optimum tension is established at any stage during the unwinding of a roll by adjustment of the nut 44, the apparatus will maintain this optimum tension not only during the remainder of the unwinding of that roll but during the unwinding of all successive rolls of the same material of substantially

the same initial roll diameter. Tests made on this apparatus show that it will maintain any desired amount of tension without variation of more than a few percent from this value during the complete unwinding of a roll of material provided that the design is properly correlated to the thickness of the material being unwound. One of the factors contributing to this smooth and accurate control is freedom of the tension control apparatus of the invention from any undue influence caused by rotation of the entire apparatus. Thus, the apparatus functions equally effective whether the roll carrier support is absolutely stationary, whether this support actually rotates (as when the material is being wound around the base element) or whether the entire apparatus is carried by some other rotating support which imparts various compound motions to the parts of the tension control apparatus.

We claim:

1. Apparatus adapted to control the tension on material being unwound from a roll comprising a roll carrier rotatably mounted on a support, friction means arranged to provide frictional resistance to rotation of the roll carrier with respect to the support, and mechanical means interconnecting the roll carrier and the support arranged to control the amount of said frictional resistance in proportion to the extent the roll carrier rotates relative to the support in the direction corresponding to unwinding of material from the roll, said mechanical means comprising an epicyclic gear train having first and second main gears provided with different numbers of teeth with the first main gear mounted in fixed position on the roll carrier support and the second main gear mounted for rotation about the axis of said support, the main gears being interconnected by an idler gear assembly mounted on the roll carrier whereby rotation of the roll carrier effects rotation of the second main gear with respect to the fixed first main gear, and means arranged to vary said frictional resistance in response to rotation of the second main gear with respect to the fixed first main gear as the roll carrier rotates with respect to said support.

2. Apparatus adapted to provide substantially constant tension on material being unwound from a roll comprising a roll carrier rotatably mounted on a support, a threaded shell mounted for rotation about the axis of the support, a tension controlling member arranged to move longitudinally along the axis of the support upon rotation of the shell with respect to the support, friction means controllably responsive to movement of the tension controlling member longitudinally along the axis of the support, and an epicyclic gear train having first and second main gears provided with different numbers of teeth, the first main gear being mounted in fixed position on the support and the second main gear being mounted on the shell, the main gears being interconnected by an idler gear assembly mounted on the roll carrier whereby rotation of the roll carrier effects rotation of the shell with respect to the support and thus effects control of the frictional resistance to rotation of the roll carrier with respect to the support by movement of the tension controlling member longitudinally along the axis of the support.

3. In apparatus adapted to provide substantially constant tension on material being unwound from a roll wherein rotation of a roll carrier with respect to its support is imparted to a threaded cylinder rotatably mounted on the axis of the support and wherein a hollow cylindrical tension controlling member engaging the threads of the cylinder is moved longitudinally along the axis of the support upon rotation of the threaded cylinder, means for providing engagement of the tension controlling member with the threads of the cylinder comprising a pawl pivotally mounted in an opening in the cylindrical wall of the tension controlling member in such manner as to be capable of moving radially through the wall into and out of contact with the threads of the cylinder, and a cylindrical guide member mounted concentrically within the tension controlling member and having an opening in its cylindrical wall so arranged as to permit recession of the pawl into said opening and out of contact with the threads of the threaded cylinder when the guide member is moved longitudinally of the axis of the support in one direction and to effect return of the pawl into engaging contact with the threads of the threaded cylinder when the guide member is moved longitudinally in the opposite direction.

4. In apparatus adapted to provide substantially constant tension on material being unwound from a roll wherein rotation of a roll carrier with respect to its support is imparted to a threaded cylinder rotatably mounted on the axis of the support and wherein a tension controlling member engaging the threads of the cylinder is moved longitudinally along the axis of the support upon rotation of the threaded cylinder, means for adjusting said tension to a fixed relative value independent of the movement of the tension control member, means for providing releasable engagement of the tension controlling member with the threads of the cylinder, means for maintaining said engagement while tension control is being effected as the tension control member moves longitudinally along the axis of the support, means for releasing said engagement to permit return of the tension control member to its starting position corresponding to initial unwinding of a roll, and registry means capable of limiting the return movement of the tension control member to its previous starting position.

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