

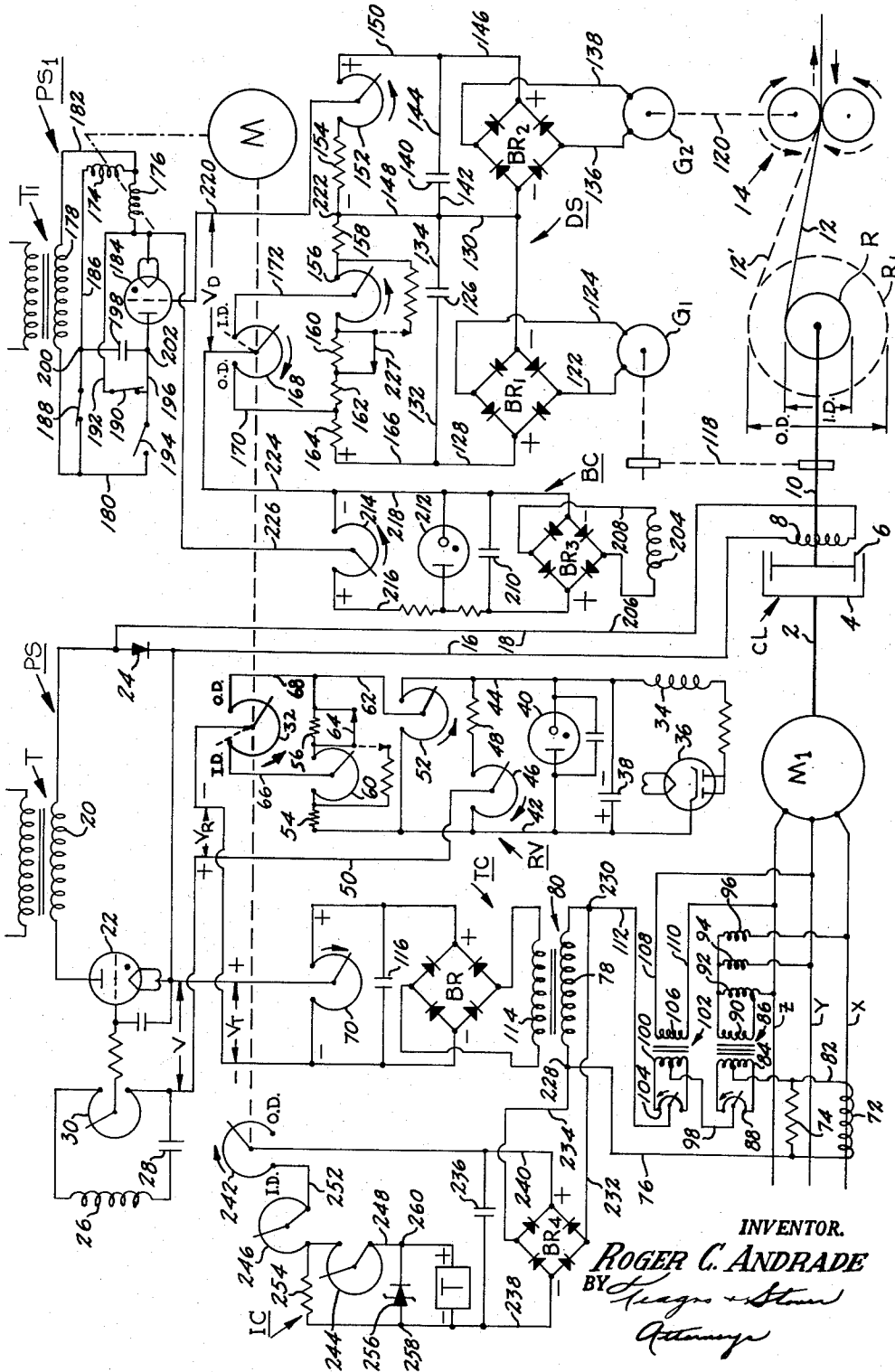
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TENSION CONTROL APPARATUS

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TENSION CONTROL APPARATUS

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This invention relates to torque controlling devices and more particularly to a control circuit for an electromagnetic coupling by which the tension upon web or strand material may be controlled in a reel winding or unwinding apparatus.

More broadly the present invention is directed to a control system for controlling the amount of tension with which a wire, strip, or web material, etc., is wound or coiled on a center-wind coiling reel. The control is directed to regulating the amount of torque which an electromagnetic coupling transmits from a constant speed motor to the reel.

It is desirable to be able to wind the web on a reel or unwind same at whatever linear web speed is produced or established by the main drive rolls. Unlike certain prior known tension control systems, the present invention provides desired tension regardless of whether the linear web speed is constant or variable.

This control is applicable where the linear speed at which the web is fed toward the reel to be wound is determined by another drive whose speed is not appreciably affected by web tension and where no looping devices or slack are desirable in the web between said drive and the reel.

As the web winds on or unwinds from the reel, tension of the web is held at a substantially constant value by varying the torque applied to the reel as the diameter of the web coiled on the reel decreases or increases, respectively.

The present invention relates to controls for apparatus of the type described and further provides for adjustment without circuit modifications, so as to obtain either constant web tension, partially tapered web tension, or fully tapered web tension.

The control system provides for an operator adjustment of the magnitude of coiling tension and governs this magnitude such that it is unaffected by web speed from stall to maximum design rating.

It is accordingly an object of the present invention to provide a control circuit for an electromagnetic coupling apparatus for regulating tension upon material being wound or unwound from a reel despite a fixed or variable rate of linear travel for the material and the changing diameter of the coil on the reel.

Another object of the invention is a provision of a tension control system which may provide, either constant web tension, partially tapered web tension, or fully tapered web tension.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawing.

The present invention is primarily concerned with center-wind systems wherein the power drive is applied to the core or center of the reel and only this system will be described in detail.

Because tension is a function of the coil diameter which is continuously changing as the material builds up on the reel, constant torque input does not give constant tension. Accordingly, a constant tension center-wind system must vary the torque input in accordance with the required function automatically in instances where loops or slack in the web between the drive rolls and the reel are undesirable. The immediate description is directed to

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a constant web tension control as the diameter of the re-wound coil increases; partially tapered web tension control and fully tapered web tension control will be herein-after described in more detail.

Referring to the drawing a tension control system is disclosed which permits automatic compensation for an increase in a coil diameter by automatically varying the output torque of an electromagetic coupling positioned between a reel and a motor drive. Two generators produce output signals proportional to the linear velocity of the web and the angular velocity of the reel, respectively.

These signals are compared and the differential signal is amplified and applied to a motor which in turn is mechanically coupled to a plurality of commonly connected potentiometers. A first potentiometer is repositioned automatically to balance the output signals of the generators; a second potentiometer is automatically adjusted to produce suitable energization of an electromagnetic coupling field winding. The first and second motor-operated potentiometers, therefore, automatically and simultaneously adjust for coil diameter changes and torque requirement variations.

A third motor-operated potentiometer is also included in the control circuit and is electrically connected to a meter to provide a visual indication of the prevailing amount of web tension being produced by the reel and its drive.

Describing now a winding operation as illustrated by the circuitry in the accompanying drawing, motor M_1 is mechanically coupled through a shaft 2 to an electromagnetic device CL including a driving member 4, a driven member 6, and a field winding 8. The device CL may be any of the conventional type couplings, such as the magnetic fluid type, but is preferably an eddy current slip clutch; M_1 may be a conventional A.C. induction motor.

An output shaft 10 mechanically couples the driven member 6 and an empty reel R. Material in the form of strip, wire, web, or the like is shown at 12 and is driven at a constant or variable linear speed by a driving means such as a pair of drive rolls 14. The web may, therefore, be considered as being fed at a relatively constant or variable speed to the reel R. The maximum outside diameter of the wound web or coil is illustrated by dashed lines R_1 in conjunction with the web 12¹ being fed from the aforementioned drive rolls.

Since the web is being fed to the reel at a constant or variable rate of speed, the angular velocity of the reel must decrease in relation to web speed as the diameter of the coil increases so as to maintain constant tension. It is also necessary to continuously increase the torque transmitted to the reel as the diameter of the coil increases, since the tension upon the material would vary with the instantaneous diameter of the coil.

Means for automatically adjusting the torque requirement is dependent upon the instantaneous diameter of the wound coil and is determined by regulating the energization of field coil 8 which is connected by means of leads 16 and 18 to a power supply source PS. The power supply includes a transformer T having a secondary winding 20, series connected to the field coil and a gas-filled grid controlled rectifier, such as a thyatron 22. A conventional back rectifier 24 is coupled across field winding 8 and provides a path for current flow through the field coil on alternate half cycles when the thyatron is in a non-conductive state.

As is conventional with power circuits of the type described, a phase shifting circuit is connected to the grid and cathode of the thyatron and includes a secondary winding 26, a capacitor 28, and a potentiometer 30. Since phase shift circuits of the type described are well

known in the art, a further description is unnecessary, it being understood that an A.C. phase shift signal is superimposed on a variable D.C. voltage component V, the latter component constituting an error signal between the desired torque and the prevailing torque.

The desired torque is established by a reference voltage circuit RV having its output voltage V_R series connected to the grid-cathode circuit of said thyatron. Also included in said series circuit is an output voltage V_T of a prevailing torque circuit TC, the polarity of which is in opposition to the output voltage V_R .

The amount of torque transmitted from the motor M_1 by the coupling CL to the reel R is related to or dependent upon the energization of field coil 8 which is dependent upon the reference voltage output signal V_R . To increase the torque output from the clutch to the reel at a rate proportional to the varying coil diameter, a potentiometer 32 in the reference voltage circuit is automatically adjusted in accordance with incremental coil diameter changes.

The reference voltage circuit includes a secondary winding 34, a duo-diode rectifier 36, and a filter capacitor 38. The rectified voltage is regulated by a voltage regulator tube 40 and this potential is applied by means of leads 42 and 44 to the reference voltage output circuit.

A low bias potentiometer 46, which may be adjusted to a desired bias setting, is series connected with a resistor 48 between leads 42 and 44 and an output lead 50 is connected to the grid circuit of thyatron 22. Also connected across leads 42 and 44 is a tension potentiometer 52 which may be operator controlled and set to varying degrees. Resistors 54 and 56 are series connected to a torque ratio potentiometer 60 across lead 42 and a lead 62 extending from the slider arm of potentiometer 52. Potentiometer 60 may be adjusted dependent upon the desired build-up ratio between coil R_1 's I.D. and O.D. In addition, a jumper lead 64 may be repositioned across certain of said aforementioned resistances or potentiometer dependent upon the desired build-up ratio between coil R_1 's I.D. and O.D. Potentiometer 32 is connected across the aforementioned torque ratio potentiometer circuit by leads 66 and 68 and its slider arm is mechanically coupled to a two-phase motor M.

The prevailing torque voltage signal V_T is derived across a potentiometer 70 in the torque circuit TC, and emanates from a winding 72 which is coupled in an inductive relationship with a single input lead of motor M_1 . Winding 72 constitutes a portion of a current transformer and the A.C. torque voltage signal obtained is related to the amount of current drawn by the motor.

A resistor 74 is coupled across said winding and one side of the current transformer output circuit is connected by means of a lead 76 to a primary winding 78 of a step-up transformer 80. The other side of the current transformer output circuit is connected by means of a lead 82 to a center tap secondary winding 84 of a reel compensation transformer 86. The portion of the in-phase voltage component which represents electro-mechanical torque losses in the motor and coupling is vectorially cancelled by adjusting a potentiometer 88 which is series connected across said secondary winding. A primary winding 90 of the reel compensation transformer is connected by means of windings 92, 94, and 96 across motor M_1 's input leads X, Y and Z.

Potentiometer 88 is connected by means of a lead 98 to a center tap secondary winding 100 of a reactive compensation transformer 102 which vectorially cancels the out-of-phase voltage component of the signal obtained by the current transformer 72. This is accomplished by adjusting a potentiometer 104 which is series connected to secondary winding 100. A primary winding 106 of the reactive compensation transformer is connected across input leads 108 and 110 to the input leads Y and Z of motor M_1 . The reactive compensation potentiometer 104

is connected to the other side of primary winding 78 by means of a lead 112.

The remaining A.C. voltage signal impressed across primary winding 78 represents the actual torque transmitted to the reel and this signal is stepped up across transformer 80 by means of a secondary winding 114 and is rectified by a bridge rectifier BR. The D.C. output of said bridge rectifier is filtered across a capacitor 116 and is applied across potentiometer 70 which may, if desired, be adjusted so as to increase the maximum available torque at the O.D. condition by adjusting its slider arm in the direction of its associated arrow.

Under a no-load condition, that is, prior to the commencement of a winding operation on an empty reel R, a desired torque is obtained by placing the slider arm of potentiometer 32 at point I.D. which represents the inside diameter of the coil to be rolled.

With the aforementioned desired reference voltage torque setting, thyatron 22 is actuated in a conventional manner upon application of A.C. voltage signals from the phase shift circuit. Field coil 8 of coupling CL is therefore energized in accordance with the reference voltage output signal V_R which, because of its polarity, conditions the grid of thyatron 22 positive with respect to its cathode. The torque transmitted by coupling CL is proportional to the amount of current flowing through its associated field winding and this torque reflects upon the torque output of motor M_1 . The actual torque transmitted by motor M_1 is detected by its associated torque output circuit TC and the resultant torque signal V_T is matched against the desired torque signal V_R in the reference circuit RV. Because of the opposing polarities of V_T and V_R the resultant torque output remains relatively stable and may only be changed by varying the reference voltage output signal V_R .

To vary the reference voltage output signal V_R upon demand of variable torque transmission requirements, the slider arm of potentiometer 32 is governed by motor M which is actuated at the instance of coil diameter variations. To accomplish this, a diameter sensing circuit DS is incorporated in the control scheme.

To properly sense coil diameter changes, two tachometer generators G_1 and G_2 , are coupled mechanically to the coupling output shaft 10 and the drive rolls 14, respectively. Tachometer generators G_1 and G_2 are preferably of the A.C. permanent magnet type and the aforesaid mechanical connections are illustrated as conventional belting means 118 and 120. Generator G_1 is connected so that its output voltage is directly proportional to the angular velocity of reel R and the output voltage of generator G_2 is directly proportional to the linear velocity of the web or strip material being fed to said reel.

Output leads 122 and 124 connect generator G_1 to a bridge rectifier BR_1 and its D.C. output is filtered across a capacitor 126, said capacitor being connected to the output of BR_1 by means of leads 128, 130, 132 and 134. Output leads 136 and 138 connect generator G_2 to a second bridge rectifier BR_2 , and the D.C. output of said bridge rectifier is filtered across a capacitor 140 which is connected to the output of BR_2 by means of leads 142, 144, 146 and 130.

The respective output voltages of G_1 and G_2 are arranged to be of opposing polarities as illustrated in the drawing. By means of leads 148 and 150, the filtered D.C. output of generator G_2 is impressed across a potentiometer 152 and resistor 154; likewise, the filtered D.C. voltage signal from generator G_1 is impressed across a potentiometer 156 and a plurality of resistors, including resistor 158, resistor 160, resistor 162, and resistor 164, by means of leads 166 and 148. A potentiometer 168 is connected by means of leads 170 and 172 across potentiometer 156, resistor 160 and resistor 162. The slider arm of potentiometer 168 is mechanically coupled to the

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output shaft of motor M, said motor being preferably of the two-phase type having its windings 174 and 176 coupled to a power amplifier circuit PS₁. Motor windings 174 and 176 are illustrated in a conventional manner at right angles to represent a 90 degree phase displacement between them.

The power amplifier circuit includes a transformer T₁ having a secondary winding 178 series connected by means of leads 180 and 182 to a gas-filled rectifier 184 of the thyatron type. Motor winding 174 is connected by means of a lead 186 through a normally closed switch 188 to lead 180. The other end of winding 174 is connected to one end of the second motor winding 176 and the other end of winding 176 is connected to the cathode side of thyatron 184 and also to the anode side of said thyatron through a normally closed switch 190 by means of a lead 192. A normally open switch 194 is connected from lead 180 to the anode of thyatron 184 by means of a lead 196 and a capacitor 198 is connected across leads 186 and 196 at points 200 and 202, respectively.

A bias circuit BC is connected to the grid-cathode circuit of thyatron 184 to control or establish a desired bias. This circuit includes a secondary winding 204 coupled to a bridge rectifier BR₃ by means of leads 206 and 208. The D.C. output of BR₃ is filtered across capacitor 210 and the output potential is regulated by voltage regulator tube 212 which supplies a relatively constant potential across a potentiometer 214 by means of leads 216 and 218.

The voltage output circuits of the respective generators G₁ and G₂ are, therefore, series connected to the output circuit of the bias circuit which in turn is applied to the grid of thyatron 184. A thyatron may, of course, be used as an "on" and "off" switch by regulating the grid potential from a D.C. source and once the bias is overcome it will conduct and will not be influenced by grid potential variations while conducting.

Tracing the grid-cathode circuit of thyatron 184, grid lead 220 extends through a portion of potentiometer 152, resistances 154 and 158, a portion of potentiometer 156, a portion of potentiometer 168, a lead 224, a portion of potentiometer 214 and thence to the cathode via a lead 226.

From the aforesaid description, it becomes readily apparent that the polarity of the output voltage circuit across generator G₁ is in a series additive relationship with the bias circuit output voltage circuit and the polarity of the output voltage circuit of generator G₂ is in series opposition to the aforementioned voltages.

When the web is being wound on the empty reel R during the start of a winding operation, the output voltages in the output circuits of generators G₁ and G₂ are arranged to be of equal magnitude and of opposite polarity. The initial magnitudes may be set by adjusting potentiometer 152 and in addition the slider arm of potentiometer 168 is placed in a start position at point I.D. representing the inside diameter of the web material. Thyatron 184 is in a cut-off state during this period of time by properly adjusting potentiometer 214 in the bias voltage circuit BC. This represents a null-balance condition wherein motor M, which is mechanically coupled to the slider arm of potentiometer 168, is not energized.

As the web commences to be fed to the reel R, the increased diameter of the coil being wound on the reel mechanically causes the reel to decrease its angular velocity with respect to the relatively constant or variable linear velocity of the web. As a result, the output voltage signal of generator G₁ decreases with respect to the output voltage of generator G₂, resulting in an unbalanced voltage condition. This unbalanced condition produces a voltage difference such as error signal V_D which, because of its magnitude and opposing polarity with respect to the bias voltage, satisfies a condition for conduction of thyatron 184. The error signal, therefore, is detected

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by the power amplifier circuit PS₁ which permits current flow through windings 174 and 176 of motor M, as long as said error signal V_D persists. As the result of motor M becoming actuated and since its output shaft is mechanically coupled to potentiometer 168, its associated slider arm is simultaneously repositioned to select a larger proportion of the output voltage signal of generator G₁ which is sufficient to equal the magnitude of the output signal of generator G₂. This results in the attainment of a null-balance condition whereby thyatron 184 is cut off and current ceases to flow through motor windings 174 and 176. The output shaft of motor M will then have a tendency to cease rotation and the slider arm of potentiometer 168 will also cease movement.

As the coil diameter increases during the winding operation, the above described process is repeated periodically or continuously, thereby causing a repositioning of the slider arm of potentiometer 168 in direct proportion to the coil diameter.

The means of sensing coil diameter variations has now been described and it becomes necessary to relate the torque and diameter variations to accurately control web tension.

As previously disclosed, the slider arm of potentiometer 32 in the reference voltage circuit is also mechanically connected to the shaft of motor M. Assuming during the commencement of a winding operation that the slider arm of potentiometer 32 is placed at a point I.D. representing an empty reel, when the shaft of motor M rotates, said slider arm will assume a position which is directly proportional to the coil diameter. Since potentiometer 32 is electrically connected in the reference voltage circuit, the reference voltage output voltage is increased by moving its associated slider arm in the direction of the arrow towards point O.D. and since the coupling field coil 8 is energized in relation thereto, the transmitted torque is therefore increased in proportion to incremental increases of the coil diameter.

Potentiometer 52 is a tension setting control and may be manually adjusted by the operator to secure a desired tension. Potentiometer 60 is a torque ratio potentiometer and may be adjusted or set for a desired ratio between the empty reel diameter I.D. and the full web diameter O.D. Since the amount of reference voltage increase (and the resultant torque increase) is adjustable in relation to the coil diameter increase (and the resultant position of potentiometer 32) an adjustment by the torque ratio potentiometer 60 will cause the output torque to (1) increase in direct proportion to the diameter, resulting in constant web tension or (2) increase in lesser proportion to the diameter, resulting in partially tapered web tension, or (3) remain constant, resulting in fully tapered web tension. If it is desirable to secure a larger build-up ratio between the empty reel diameter and the full coil diameter, it may be preferable to reposition jumper lead 64, as illustrated by its dashed arm, to vary the resistance in the reference voltage circuit. Jumper lead 227 in the diameter sensing circuit DS may also be repositioned for a comparable ratio build-up or change.

By merely presetting torque ratio potentiometer 60 to a desired position, it therefore becomes apparent that the control system provides, without circuit modifications, (1) constant web tension as the diameter of the rewind coil increases by automatically increasing the applied torque in direct linear proportion to the increased coil diameter or (2) a partially tapered web tension which decreases as the coil diameter increases, which automatically increases the output torque in a lesser linear proportion to increases in the coil diameter or (3) a fully tapered web tension which decreases as the coil diameter increases by automatically maintaining constant output torque.

By utilizing the aforementioned potentiometers 32 and 168 in the respective reference voltage and diameter sensing circuits, the invention permits automatic com-

pensation for variations in the coil diameter and automatically adjusts the output torque of the electromagnetic coupling. In view of the mechanical relationship existing between the aforementioned coupled potentiometers and the associated driving motor M, the system provides a unique memory in the event reel R ceases to rotate. Information relating to the coil diameter in a temporarily stopped position is retained by the settings on potentiometers 32 and 168, respectively, and upon resumption of rotation of reel R, the control system will proceed from the aforementioned setting. This results in a diameter memory system.

When the desired coil diameter is reached, potentiometers 32 and 168 must be reset to the starting positions, identified at points I.D., by reversing the current flow through motor windings 174 and 176. A switching means is provided for this reversal which is accomplished by opening normally closed switches 188 and 190 and closing normally open switch 194.

Although the system has been heretofore described as directed to a winding operation on a center-wind type coiling reel, the system is equally applicable to systems requiring the control of web tension where the material is being unwound from the reel. In an unwind operation, the web 12¹ is unwound from a pay-off reel R and since the diameter of the web material will now decrease as it is being unwound, it is necessary to initially set the slider arms of potentiometers 32 and 168 to their appropriate O.D. positions which represent the proper ratio between the inside and outside diameters of the coil to be unwound. In an unwind operation the direction of rotation of the drive rolls 14 is reversed as indicated by the dashed arrows and the web material is being fed at a relatively constant linear speed in an opposite direction. In this environment the coupling performs a braking function and the transmitted torque is decreased proportionally with a decrease in the web material diameter so as to maintain constant tension.

In an unwind operation where the braking clutch function or back tension in the web is desired, the direction of rotation of the drive rolls 14, reel R and coupling member 6 are reversed; the direction of rotation of coupling member 4 and motor M, remain the same as in a winding operation.

A circuit modification (not shown) for an unwinding operation requires that the lead extending from the slider arm of potentiometer 168 be connected directly to the grid of thyatron 184 rather than to lead 224; in addition, lead 220, rather than being connected directly to said grid, is connected directly to lead 224 in the bias circuit. As hereinbefore disclosed, the slider arms of potentiometers 32 and 168 are initially set to their respective O.D. positions and are driven towards their respective I.D. positions during an unwinding operation. This may be accomplished in any conventional manner such as changing the electrical connections of motor M's winding or by appropriate gearing means.

A visual tension indication circuit IC is also included in the control. The A.C. input voltage to said circuit is connected across torque output leads 76 and 112 at points 228 and 230. The torque voltage signal is coupled to a bridge rectifier BR₄ means of leads 232 and 234 and the D.C. output of said rectifier is filtered across a capacitor 236. Said capacitor is connected across BR₄ by means of leads 238 and 240. One end of capacitor 236 is connected to the slider arm of a potentiometer 242 and the other side of said capacitor is connected to one side of a current sensitive meter T in a series relationship to a meter adjustment potentiometer 244 and thence to a meter ratio potentiometer 246 by means of a lead 248. The other side of meter ratio potentiometer 246 is connected to one side of potentiometer 242 by means of a lead 252. A protective resistance 254 is shunted across the meter T and potentiometer 244, and a Zener diode

256 is connected across the aforementioned meter at points 258 and 260.

With the tension meter established at the desired tension by the adjustment of potentiometer 244 at the commencement of the winding operation, the slider arm of potentiometer 242 is placed at point I.D. Since slider arms of potentiometers 242, 32 and 168 are commonly and mechanically connected to the output shaft of motor M, the slider arm of potentiometer 242 moves in unison with the slider arms of the aforementioned potentiometers when motor M is actuated, and it assumes a position directly proportional to an increase in the coil diameter during a winding operation. Because potentiometer 242 is electrically connected in series with the current sensitive meter T, the total amount of electrical resistance is changed in proportion to an increase in the web diameter.

As the coil diameter increases, a larger torque signal is developed in the torque meter circuit; however, the slider arm of potentiometer 242 simultaneously moves in a direction towards point O.D. and the total amount of electrical resistance in the motor circuit is also changed in proportion to coil diameter variations. To secure a relatively constant tension meter reading, the current flowing through the current sensitive meter must remain substantially constant and since applied torque voltage signal increases proportionally to the applied resistance change in potentiometer 242, this condition is accomplished.

The resultant current flow through the meter is thus proportional to the quotient of the reel torque and the coil diameter, which in turn is proportional to the desired web tension. The meter T is thus caused to indicate a value which is proportional to the web tension.

It is seen by the foregoing description that the tension control system not only continuously senses coil diameter changes but it automatically and continuously regulates variable torque output requirements by actuating a plurality of conjointly rotatable potentiometers from a common prime mover. The prime mover, which is sensitive to incremental coil diameter changes, also regulates a visual tension meter.

It may be readily appreciated, therefore, that the control system provides a plurality of null-balance circuits. A first null-balance circuit senses incremental coil diameter variations and produces a differential or error signal which activates a prime mover when said first circuit is in an unbalanced state. The prime mover mechanically adjusts a variable resistance or rheostat in said null-balance circuit to condition the circuit towards a balanced state thereby tending to cancel the error signal and simultaneously inactivating the prime mover. A second null-balance circuit senses coupling torque variations between desired torque and prevailing torque and produces a second differential or error signal when the prevailing torque is less than the desired torque. Energization of the coupling's field coil is responsive to said second error signal when said second circuit is in an unbalanced state and the circuit is conditioned towards a balanced state when the prevailing torque approaches the desired torque.

Since the desired torque requirement is continuously changing due to coil diameter variations, a rheostat is included in the second null-balance circuit and is mechanically adjusted by said prime mover to condition said second circuit towards an unbalanced state thereby tending to produce an error signal which in turn varies the energization of said field coil dependent upon varying coil diameter.

The prime mover which is actuated by the error signal in said first null-balance circuit therefore conditions said first null-balance circuit towards a balanced state and simultaneously conditions said second null-balance circuit towards an unbalanced state dependent upon incremental coil diameter variations.

In the specification and appended claims, the term constant web tension defines a condition wherein the ap-

plied torque increases in direct proportion to increases in the coil diameter and results in substantially no taper in web tension. The term fully tapered web tension refers to operating conditions wherein the applied torque remains substantially constant and web tension decreases or tapers off in inverse proportion to increases in the coil diameter. Partially tapered web tension during coil build-up is defined as a decrease in web tension of a lesser magnitude than the full taper as defined above.

In view of the above, it will be understood that the several objects of the invention have been achieved and other advantageous results obtained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What I claim is:

1. A control for regulating tension in a system having a rotary reel upon which a web is wound or unwound at a relatively constant or variable linear speed, the control comprising an electromagnetic coupling having a field coil, a motor driving said coupling and said coupling connected to said reel, a power source connected to said field coil, first and second variable resistances, a prime mover responsive to a coil diameter sensing circuit including means for producing an error signal determined by variations between the linear web speed and the angular velocity of said reel, said error producing means including said first variable resistance mechanically coupled to said second variable resistance and responsive to resistance variations at the instance of variations of said second resistance, means connected to said power source for regulating the energization of said coil commensurate with the torque transmitting requirements of said coupling, said means including said second variable resistance mechanically coupled to said prime mover and responsive to resistance variations upon actuation of said prime mover, said first resistance variations having a tendency to inactivate said prime mover whereby the tension of the web is continuously controlled by regulating the transmitted torque in response to coil diameter variations.

2. A tension control as set forth in claim 1, which further includes an adjustable means for presetting the control in a reel winding operation to secure constant tension, partial taper or full taper, said means including a third variable resistance electrically connected to said second variable resistance.

3. A tension control as set forth in claim 1, which further includes means for producing a voltage signal proportional to transmitted torque, a current sensitive meter and a third variable resistance connected to said torque voltage signal means, said third variable resistance responsive to resistance variations upon actuation of said prime mover, whereby a visual tension indication is obtained proportional to variable torque voltage signals and resistance variations of said third variable resistor.

4. In a web tensioning apparatus having a prime mover, a reel having a web wound on or unwound thereon at a substantially constant or variable rate of linear travel, an electromagnetic coupling having a field coil, said prime mover drivingly coupled to said coupling, and said coupling connected to said reel, a tension control comprising an energizable motor having a rotatable shaft, first and second resistances conjointly variable proportional to the angular displacement of said motor shaft, a coil diameter sensing means including first and second generator output circuits for producing an error signal between the angular velocity of said reel and the linear speed of said web respectively, said first resistance electrically connected to said first generator output circuit, said motor responsive to said error signal to mechanically vary said first resistance which tends to cancel said error signal, a reference voltage circuit means, means including said second resistance electrically connected to an output circuit of

said reference means whereby the energization of said field coil and the output torque of said coupling are varied in relation to coil diameter variations.

5. A tension control as set forth in claim 4, which further includes means for amplifying said error signal and switching means for controlling the direction of rotation of said motor shaft.

6. A tension control as set forth in claim 4, which further includes a third variable resistance, said resistance electrically connected to said second resistance and adjustable for reel winding operations to produce constant web tension and an infinite number of web tension tapers.

7. A tension control as set forth in claim 4, which further includes a third resistor variable conjointly with said first and second resistances, a current sensitive tension indicator device, a torque circuit means for producing a torque voltage signal proportional to said coupling's output torque variations, said indicator device responsive to said torque signals and resistance variations of said third resistance.

8. An electrical control system for maintaining tension on a web being wound on or unwound from a rotary reel at a substantially uniform or variable rate of linear speed, a first prime mover, an electromagnetic coupling connecting said prime mover with said reel, a field coil for energizing said coupling to vary the coupling between said prime mover and said reel, the control comprising a coil diameter sensing means including a null-balance circuit having a first generator driven by said reel to produce a first D.C. voltage signal proportional to the angular velocity of said reel, means for feeding said web to said reel, a second generator driven by said feed means to produce a second D.C. voltage signal proportional to the linear speed of said web, circuit means connected to said generators including a first variable resistance for detecting a first error signal between said first and second D.C. voltage signals, a second prime mover having a rotatable shaft responsive to said first error signal, said first variable resistance responsive to the angular displacement of said shaft to condition said null-balance circuit, a reference voltage circuit means having a D.C. voltage output signal for regulating the energization of said field coil dependent upon instantaneous coil diameter variations, said reference voltage circuit means including a second variable resistance responsive to the angular displacement of said shaft, means connected to said reference voltage circuit means for producing a D.C. voltage signal proportional to the prevailing torque of said coupling and means for detecting a second error signal between said prevailing torque signal and said reference signal for controlling the output torque of said coupling proportional to incremental coil diameter changes.

9. A control system as set forth in claim 8 wherein said reference means further includes a third variable resistance electrically connected to said second resistance, the setting of said third resistance cooperating with said second resistance to establish a desired one of an infinite number of variable web tensions, including constant web tension, partially tapered web tension, and fully tapered web tension.

10. A control system as set forth in claim 8, which further includes a third variable resistance responsive to the angular displacement of said shaft, a current sensitive indicator means connected to said third resistance and to said prevailing torque voltage means, said indicator means responsive to proportional variations of said third resistance and said torque voltage.

11. A control system as set forth in claim 8 wherein said output torque controlling means includes a power amplification source connected to said field coil, the energization of said field coil responsive to said second error signal.

12. A control as set forth in claim 8, wherein said second prime mover includes energizable windings, a power amplification source connected to said windings and

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the energization of said windings responsive to said first error signal.

13. A control for regulating constant tension in a system having a web wound on or unwound from a reel at a relatively constant or variable linear speed, a motor, an electromagnetic coupling having a field coil, said coupling driven by said motor and said coupling connected to said reel, the control comprising means for controlling torque between said coupling and said reel by energizing said field coil, said means including first and second null-balance circuits, said first null-balance circuit including a first mechanically actuatable rheostat, said second null-balance circuit including a second mechanically actuatable rheostat, means for producing a first error signal in said first null-balance circuit, means for producing a second error signal in said second null-balance circuit, the energization of said field coil responsive to said second error signal, said first and second error signals proportional to incremental coil diameter variations, a prime mover having a rotatable shaft responsive to said first error signal, said first and second rheostats responsive to resistance variations proportional to the rotation of said shaft, whereby said first and second null-balance circuits are conditioned in response to actuation of said prime mover to continuously control tension by regulating torque in response to coil diameter variations.

14. In a web tension apparatus for controlling tension on a web being wound on or unwound from a reel at a relatively constant or variable linear rate of travel, a prime mover, an electromagnetic coupling having a field coil, said coupling connected between said prime mover and said reel for regulating transmitted torque to said reel by varying the energization of said field coil, a control comprising means including a null-balance circuit for continuously sensing incremental coil diameter variations, means for continuously sensing variations between a desired coupling torque and a prevailing coupling torque, means responsive to an unbalanced condition in said null-balance circuit to simultaneously condition said null-balance circuit and said torque sensing means whereby the output torque of said coupling is varied proportionally to coil diameter changes.

15. In a web tension apparatus for controlling tension on a web being wound on or unwound from a reel at a relatively constant or variable linear rate of travel, a prime mover, an electromagnetic coupling having a field coil, said coupling connected between said prime mover and said reel for regulating transmitted torque to said reel by varying the energization of said field coil, a control comprising means including a null-balance circuit for continuously sensing variations between a desired coupling torque and a prevailing coupling torque, means for continuously sensing incremental coil diameter variations, means responsive to the output of said coil diameter sensing means to simultaneously condition said null-balance circuit and said coil diameter sensing means, whereby the output torque of said coupling is varied proportionally to coil diameter changes.

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16. In a web tension apparatus for controlling tension on a web being wound on or unwound from a reel at a relatively constant or variable linear rate of travel, a prime mover, an electromagnetic coupling having a field coil, said coupling connected between said prime mover and said reel for regulating transmitted torque to said reel by varying the energization of said field coil, a control comprising means including first and second null-balance circuits, said first null-balance circuit including means for continuously sensing incremental coil diameter variations, said second null-balance circuit including means for continuously sensing variations between a desired coupling torque and a prevailing coupling torque, means responsive to an unbalanced condition in said first null-balance circuit to simultaneously condition said first and second null-balance circuits, whereby the output torque of said coupling is varied proportionally to coil diameter changes.

17. In a control as set forth in claim 16, wherein said coil diameter sensing means includes first and second generator output circuits, a first variable rheostat connected to said output circuits, said rheostat mechanically coupled to said conditioning means.

18. In a control as set forth in claim 17, wherein said torque sensing means includes a reference torque voltage output circuit and a prevailing torque voltage output circuit, a second variable rheostat connected to said torque voltage output circuits, said rheostat mechanically coupled to said conditioning means.

19. In a control as set forth in claim 18, which further includes a third variable rheostat mechanically connected to said conditioning means, a current sensitive meter, said prevailing torque output circuit connected to said meter and said third rheostat.

20. In a web tension apparatus for controlling tension on a web being wound on or unwound from a reel at a relatively constant or variable linear rate of travel, a prime mover, an electromagnetic coupling having a field coil, said coupling connected between said prime mover and said reel for regulating transmitted torque to said reel by varying the energization of said field coil, a control comprising means including first and second null-balance circuits, said first null-balance circuit including means for continuously sensing incremental coil diameter variations, said second null-balance circuit including means for continuously sensing coupling torque variations, means responsive to an unbalanced condition in said first null-balance circuit to simultaneously condition said first and second null-balance circuits, whereby the output torque of said coupling is varied proportionally to coil diameter changes, said second null-balance circuit further including means for establishing a desired one of an infinite number of variable web tensions.

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