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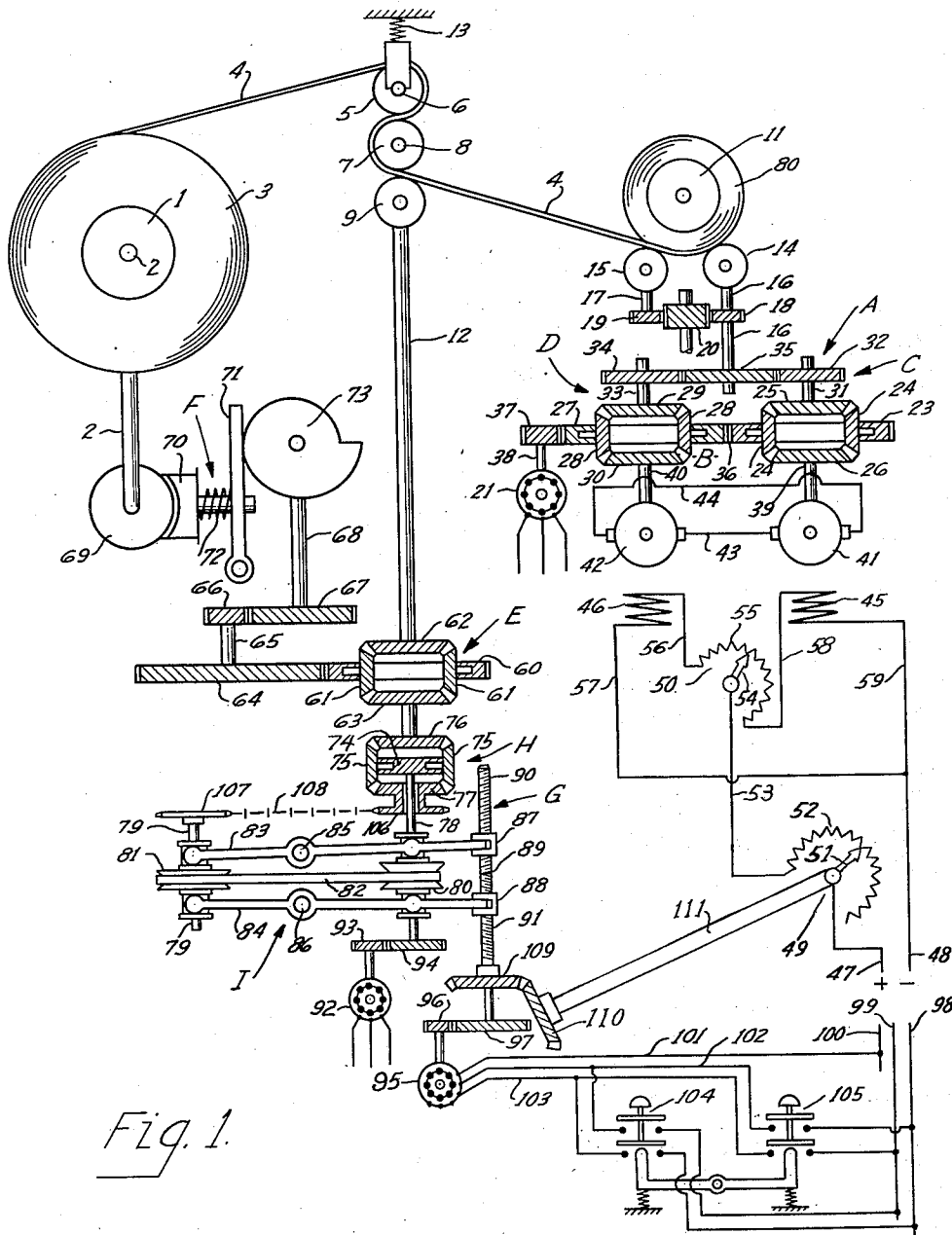
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2,639,868

STRIP MATERIAL WINDING APPARATUS

Filed Nov. 29, 1951

2 Sheets-Sheet 1



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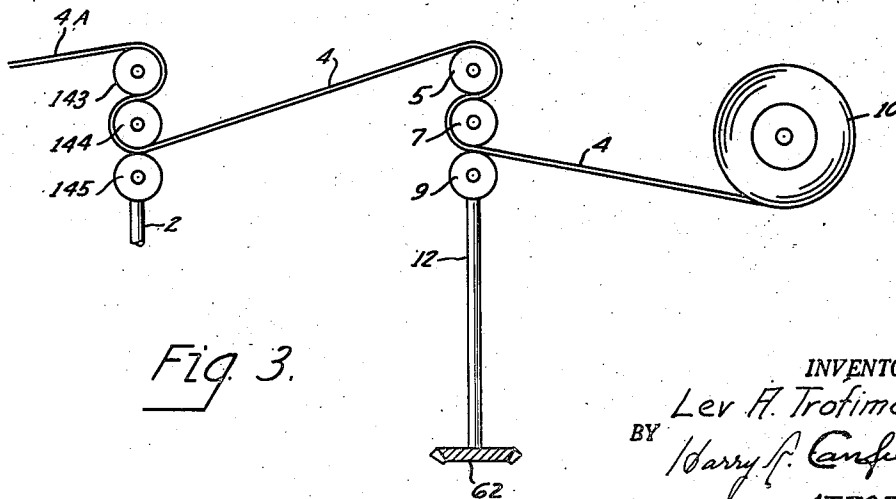
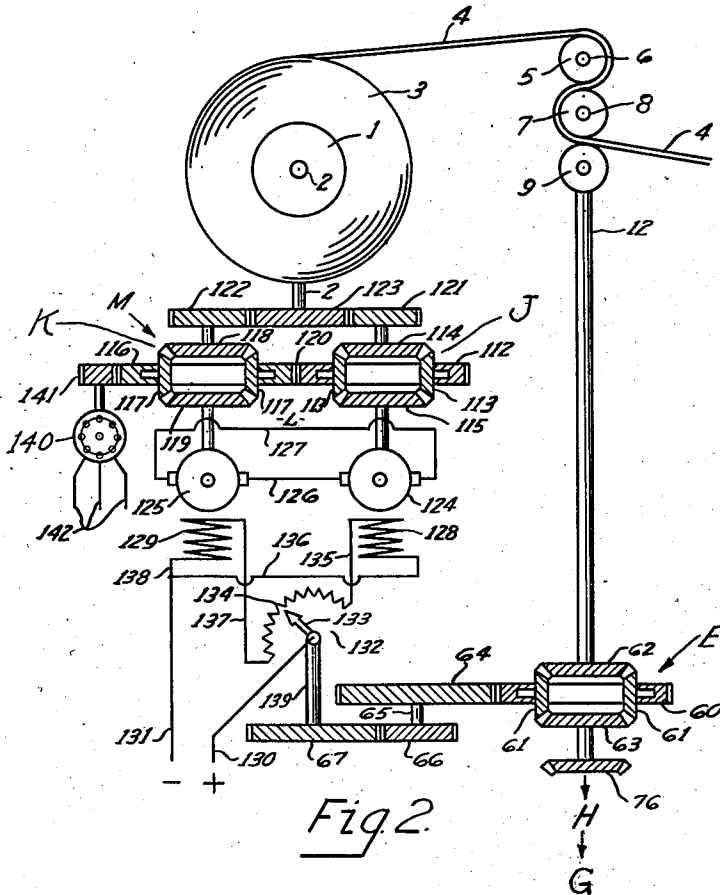
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STRIP MATERIAL WINDING APPARATUS

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UNITED STATES PATENT OFFICE

2,639,868

STRIP MATERIAL WINDING APPARATUS

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Application November 29, 1951, Serial No. 258,904

16 Claims. (Cl. 242-75)

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This invention relates to winding apparatus for winding strip material on a drum or the like.

The invention is particularly applicable to unwinding strip material from a coil on a supply drum or the like, and rewinding it in a coil on another drum or the like, and will hereinafter be described as applied to that use.

There are well known uses for such apparatus in various industrial arts.

Apparatus of this class has been proposed heretofore; but problems have arisen which have not been satisfactorily solved by such prior apparatus.

Among such problems has been that of maintaining a desired tension in the strip being wound and a desired speed of winding, the problem originating in the increasing diameter of the roll as winding goes on.

It is desirable for a single apparatus to be usable to rewind various different kinds of material at different times. Some materials dictate a low speed, whereas others may advantageously be wound at high speed; and some materials require high tension in the strip being rewound, and such tension in strips of other materials cannot be permitted.

In some prior apparatus of this class, adjustments of strip speed and tension have been proposed, but the provision of adjustments that can be accurately and sensitively made and that will thereafter remain fixed, particularly adjustments of strip tension and speed independently of each other, whereby any desired tension may be had at any desired speed and over wide ranges of tension and speed, has not been satisfactorily accomplished in prior apparatus.

It is an object of the present invention to provide an apparatus of the class referred to which overcomes the foregoing and other objections to prior apparatus.

Another object is to provide a strip winding apparatus having improved means for adjusting the strip speed, and for maintaining it constant.

Another object is to provide a strip winding apparatus having improved means for adjusting the strip tension and for maintaining it constant.

Another object is to provide a strip winding apparatus having improved means for adjusting the speed and tension of strip material being wound, either one alone and independently of the other, or both concurrently.

Another object is to provide improved power means for driving the winding drum of a strip winding apparatus.

Another object is to provide improved means for tensioning strip material while being wound.

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Another object is to provide improved means for automatically controlling the tension of strip material being wound, responsive to speed of the strip.

Another object is to provide, in a strip winding apparatus, strip speed controlling means comprising improved adjustable speed-reference means.

With these objects in view, and others that will occur to those skilled in the art which will become apparent hereinafter, the apparatus in an illustrative embodiment of the invention and to be described in detail, comprises, generally speaking, the following parts.

A power unit drives a winding drum to wind strip thereon, drawing it from a supply drum on which it has been previously wound. The power unit is of a type that has such torque-speed characteristics that if its output torque rises, its output speed falls; and vice versa; so that in general, when the delivered torque is high, the speed is low, and vice versa; and the unit will deliver torque over a wide range from maximum torque at zero speed to substantially zero torque at maximum speed. For any delivered output torque there is a certain predetermined output speed.

The power unit furthermore is adjustable so that the value of the output torque corresponding to a given speed may be increased or decreased.

The torque of the driving unit is applied to the outer circumference of the coil being wound, so that regardless of increase of diameter of the coil as winding goes on, if constant torque is applied to the coil, it is converted into constant tangential pull longitudinally of the strip material as it approaches the winding drum.

This pull or longitudinal force on the strip reacts upon the unwinding drum from which the material is being drawn, and rotates it; and the rotation of the unwinding drum is retarded by a braking apparatus; and it is by this means that torque output of the power unit produces tension in the strip.

Strip speed responsive apparatus is provided actuated by the speed of the strip to vary the braking action on the unwinding drum, tending to increase the braking action upon an increase of strip speed and decrease it upon a decrease of strip speed.

A speed-reference power unit is provided having a fixed output speed which can be preset by adjustment at any desired fixed speed.

The braking action on the wound drum produced by the braking apparatus, responds jointly to the constant set speed of the speed reference

unit and to the speed of the strip, whereby the strip speed is maintained constant, and the value of the constant speed can be selectively adjusted.

With the speed reference unit adjusted for strip speed of some selected constant value, the torque of the power unit corresponding to that speed will develop constant tension in the strip of a corresponding value. Upon adjusting the power unit to change its torque output at that speed, the tension in the strip may be adjusted without changing its speed; whereby for any chosen speed of winding, the strip may be wound with any desired tension. And by adjusting both the speed reference unit and the torque of the power unit, the strip may be wound at any desired speed and any desired tension; whereby, a given apparatus may be adjusted to wind at low strip speed and high tension, or high strip speed and low tension, or at any intermediate values of speed and tension, over a wide range of speed and tension; to adapt the apparatus to the requirements of different materials.

The adjustment means of the speed reference unit and that of the power unit are interconnected so that the strip can be wound at a pre-selected tension at one speed and then the speed changed without changing the tension.

The invention is described generally in the foregoing and an embodiment thereof will be described in detail, but the actual invention is that set forth in the appended claims.

The said preferred embodiment is fully disclosed in the following description taken with the accompanying drawing in which:

Fig. 1 is a view illustrating somewhat diagrammatically the said embodiment of the invention;

Fig. 2 is a fragmentary view of a part of Fig. 1, illustrating a modification;

Fig. 3 is a fragmentary view of a part of Fig. 1 illustrating a different application of the invention.

The diagrammatic drawing illustrates rotary gears, shafts etc., but the bearings therefor have been omitted for simplification; and as being known and understood.

There is shown at A a drum rotatably supported on a shaft 2 and having a coil 3 of strip material 4 wound thereon; the strip 4 leaving the coil tangentially and going over a cylindrical roll 5 on a shaft 6, then between the roll 5 and a roll 7 on a shaft 8, and between the roll 7 and a roll 9; and therebeyond as shown is being wound in a coil 10 on a winding drum 11.

The roll 9 is supported by a shaft 12, and the rolls 5 and 7 are maintained in vertical alignment by guides not shown, and are held downwardly by gravity or by spring means 13 or other suitable means not shown but well known; and thereby the strip 4 is gripped between the rolls 5-7 and 7-9.

By this means when the strip 4 is being wound on the drum 11 and moves linearly through the rolls, it drives the roll 9, and is prevented from slipping thereon and thereby drives the shaft 12, always at a speed corresponding to the linear speed of the strip 4.

The coil 30 at its outside perimeter rests by gravity upon a pair of spaced cylindrical rolls, 14-15 of equal diameter, mounted on shafts 16-17. The roll 14 is driven directly by power supplied to the shaft 16; and by means of like gears 18-19 on the shafts 16-17 meshed with an intermediate gear 20, the roll 15 is driven; and therefore both rolls 14-15 are driven at the same speed and in the same direction; and the

rolls 14-15 rotatably drive the coil 10 by frictional contact with its periphery.

The rolls 14 and 15 are part of a driving power-unit shown generally at A and comprising a motor 21, running continuously at substantially constant speed, a squirrel cage induction motor as shown being preferred; and comprising a differential gear transmission indicated generally at B, transmitting motor power to the shaft 16.

The transmission B comprises two differential gearings C and D, preferably alike. The gearing C comprises a spider gear element 23, rotatably supporting pinion gears 24-24, meshed with two differential gears 25 and 26.

The gearing D comprises a spider gear element 27, rotatably supporting pinions 28-28, meshed with two differential gears 29 and 30.

A shaft 31 connects a gear 32 to the differential gear 25; a shaft 33 connects the differential gear 29 to a gear 34; and the two gears 32 and 34 are meshed with an intermediate gear 35 on the shaft 16.

The two spider elements 23 and 27 are preferably of the same diameter, and have teeth on their perimeters, meshed together at 36; and a pinion 37 on a shaft 38 of the motor 21 meshed with the spider element 27; whereby the motor drives both spider elements 27-23, in opposite directions at the same speed.

The differential gears 26-30 are connected respectively by shafts 39-40 to electrodynamic units 41-42 having the construction of direct current generators.

The generators have a local closed series load circuit connected to their brushes, comprising wires 43-44.

The generators 41-42 are preferably alike and have separately excited field windings 45-46 respectively energized at the same polarity from direct current mains 47-48, through rheostats 49-50; the path of the current for the field winding 46 being from the main 47, through a movable rotary contact 51 of the rheostat 49 and a part of its resistor 52 by wire 53 through a rotary contact 54 of the rheostat 50 and part of its resistor 55, by wire 56 through field winding 46 and back by wire 57 to the main 48; and the current path for the field winding 45 being from the main 47 as before to the contact 54 of rheostat 50 and part of its resistor 55, then by wire 58, through field winding 45 and back by wire 59 to the main 48.

At E is a differential gearing, comprising a spider element 60, rotatably supporting pinions 61-61, meshed with differential gears 62-63, the differential gear 62 being connected to the shaft 12 and driven thereby.

The spider element 60 has peripheral teeth meshed with a gear 64 on a shaft 65 connected to a gear 66 meshed with a gear 67 connected to a shaft 68; and rotation of the spider element 60 thus drives the shaft 68.

At F is a brake mechanism for the wound drum 1, comprising a brake drum 69 on the shaft 2, a brake shoe 70 held against the brake drum 19 by a pivoted arm 71 and a spring 72 between the arm and the brake shoe; and a cam 73 on the shaft 68, upon alternate rotation thereof, rocks the arm 71 to produce variable braking effect on the drum 69 by the shoe 70.

At G is shown generally a speed reference unit. It comprises a differential gearing H having a spider element 74, rotatably supporting pinions 75, meshed with differential gears 76-77; and comprises a variable speed transmission unit shown generally at I comprising a pair of parallel shafts

78—79 having expansible and contractable belt pulleys 80—81 splined thereto connected by a belt 82, and operable to be oppositely contracted and expanded axially, by rocking levers 83—84 pivotally supported at 85—85 and engaging the pulleys 80—81 on opposite sides of the pivots; the levers 83—84 extending beyond the pulley 80 and engaged with threaded nuts 87—88 on a screw 89 having right hand and left hand threads 90—91; whereby upon rotation of the screw 89, the nuts 87—88 will be propelled oppositely along the screw, and the levers 83—84 will be oppositely rocked, and expand the diameter of one of the pulleys 80—81 and contract that of the other, to change their relative diameters and speed ratio.

A power input motor 92, preferably one that runs at substantially constant speed, a squirrel cage induction motor being preferred, is connected to the shaft 78, through gears 93—94.

The motor 92 runs continuously, rotating the shaft 78 at substantially constant speed and, by the belt 82, drives the shaft 79 at different speeds corresponding to the relative diameters of the pulleys 80—81.

The screw 89 is rotatable in alternate directions as referred to by a reversible adjusting motor 95 connected to it through gears 96—97. Any suitable motor and reversing control therefor may be provided, that shown comprising a squirrel cage induction motor 95, connected to supply mains 98—99—100, by wires 101—102—103 through forward and reverse push button contactors 104 and 105.

Normally the contactors 104 and 105 are open and the motor 95 at rest. Upon closing one contactor the motor 93 starts and runs in one direction and upon closing the other it runs in the other direction, the electrical reversing connections shown being conventional, and not requiring description in detail.

The spider element 74 of the differential gearing H is connected to the shaft 78, and the differential gear 77 is connected to a chain sprocket wheel 106; and the shaft 79 has a sprocket wheel 107 connected thereto, aligned with the sprocket wheel 106, and a sprocket chain 108 connects the two sprocket wheels, 106 and 107.

The part of the variable speed transmission shown at I will be recognized as one of the "Reeves" type; but such a transmission has been chosen for illustrative purposes, only; and as such is not an essential part of the invention; and it will be understood that any other type of variable-speed-ratio transmission may be used with which the mechanical connections to the differential gearing E can be made and which has a rotary speed ratio adjusting element corresponding to the screw 89.

The screw 89 has a gear 109 thereon meshed with a gear 110 connected to one end of a rotary shaft 111, the other end of which is connected to the rotary contact 51 of the rheostat 49.

The operation of the above described apparatus will now be given.

As to the transmission part B, of the power unit A, a general description of such apparatus as a reversing power unit may be found in the patent of Lev A. Trofimov, Number 2,464,275, issued March 15, 1949; and in view of that patent a brief description will suffice here, although here the direction of the torque output is always in one direction.

Current to the separately excited field windings 45—46, comes to the rotary contact 54 of the rheostat 50 by the wire 53; and there divides, going to the respective field windings 45—46

through respective parts of the resistor 55, as described.

For purposes of description it will here be first assumed that the contact 54 is on some mid-point of the resistor 55, and that the two field windings are equally energized, or at least energized relatively to cause the generators 41—42 to produce equal output voltages when driven at the same speed.

Preferably the two differential gearings C and D are alike as to size of gears etc. The spider 23 applies equal torques to the gear 32 and to the generator 41; and the spider 27 applies the same equal torques to the gear 34 and the generator 42. The gears 32 and 34 tend to be driven in opposite directions, and, being subjected to equal torques and both meshed with the gear 35, they apply their equal torques to the gear 35 in opposite directions, and are held from rotating thereby; and the generators 41—42 therefore will be driven, and in opposite directions and at twice the speed of the spiders 23—27. The generators 41—42, generate opposite equal voltages in the load circuit 43—44, and therefore no load current flows; and all torques are therefore negligibly small, in these assumed idling conditions.

If now, more as in practice, the contact 54 be rotated from its assumed mid-position, clockwise, as viewed in the drawing, energization of the field winding 45 will be increased and that of winding 46 decreased; the voltage of the generator 41 will exceed that of generator 42; and load current will flow from generator 41 in the load circuit 43—44 through the generator 42, causing it to act as a motor.

The generator 41, now being loaded, requires more torque to drive it, and it takes this increased torque from the spider 23, and an equal increased torque is developed on the gear 32, tending to drive it in the same direction as the generator 41.

The generator 42, now a motor, develops motor torque without changing its direction of rotation, which is opposite to that of the generator 41; and this motor torque communicated to the gear 30 causes it to react on the spider 27 and apply the torque to differential gear 29 and gear 34 in the direction opposite to that of the assumed idling conditions, thus tending to drive the gear 34 in the same direction as the gear 32. The torque of gears 32 and 34 are thus applied to the gear 35 both in the same direction and the gear 35 and the shaft 16 are rotatably driven thereby; and, as described, the coil 10 is thereby driven in the winding direction by the shaft 16.

From the foregoing it will be seen that if the output shaft 16 be at rest or rotating at low speed, the generator and motor speeds will be high and the torque applied to the shaft 16 will be high; and that at higher and higher speeds of the output shaft 16, the torque applied to it will be correspondingly less and less; this being the output torque-speed characteristic of the unit A.

For each certain speed of the shaft 16 therefore it delivers a corresponding certain torque; and the actual value of the delivered certain torque may be changed by changing the position of the rotary contact 54.

Current to the field windings 45—46, at any setting of the contact 54, flows to the contact 51 and through part of the resistance 52, of rheostat 49. If the contact 51 be moved to cut out some of the resistance 52 it will increase the field strength of generator 41 and increase its

generated load current and the torque to drive it, and hence increase the torque on shaft 16 as described. The torque-speed characteristic above described will not be changed thereby, but all values of delivered torque will be increased.

Thus as will be apparent from the foregoing, the torque of output shaft 16 may be kept at a constant value for different certain speeds by movement of contact 54; and the actual amount of said constant torque value at such speeds can be changed by moving contact 51.

Assuming now that, as in practice, the power unit A is running and that the rheostat 50 is adjusted as described to cause the shaft 16 to apply torque to the coil 80 through the rolls 14—15 to drive it; the strip 4 will be drawn from the coil 3, and will drive the roll 9 and thereby shaft 12 and differential gear 62 of gearing E.

The gear 62 reacting on the differential gear 63 will drive the spider 60, and, through the gears 64, 66, 67 and shaft 68, will rotate the cam 73 of the brake mechanism F in the direction to exert more braking action on the brake drum 69.

In the absence of any corrective provision, this would slow down the strip speed more and more, and slow down the drive shaft 16 at the unit A more and more and cause the torque at shaft 16 to rise more and more and develop continuously increasing tension in the strip 4.

However, in practice, the unit G is also in operation, being driven by the motor 92. The shaft 78 thereof rotates the spider 74 of the gearing H, directly, and rotates the differential gear 77 at a speed determined by the rotated position of the screw 89 of the unit I; so that the differential gear 76 of the gearing H has a corresponding rotary speed, and it rotates the differential gear 63 of the gearing E in the direction opposite to that of the differential gear 62 driven by the strip 4.

The speed of differential gear 76 may be adjustably changed by changing the speed of gear 77 and this is done by rotating the screw 89 of the unit I by momentarily closing either the contactor 104 or the contactor 105; and thereby the speed of differential gear 76 and 63 connected together, may be increased or decreased. This may be considered as a pre-set adjustment, and when the speed of the differential gear 62, of the unit E is equal to the speed of the gear 63, the spider 60 will cease to rotate and the brake action will stop changing, and thus a constant adjusted or pre-set speed of the strip will be maintained.

When winding of the strip begins, a desired speed and tension for the strip may be chosen. The power unit A by its output shaft 16, draws the strip 4 from the coil 3, and produces tension in the strip due to the said braking action. The speed of the strip may be adjusted as described to the chosen value. The tension in the strip at that speed may be adjusted to the chosen value by adjusting the rheostat 50, and the strip will then have the chosen speed at the chosen tension.

If now it be desired to change the speed of the strip without changing the strip tension, this is provided for as follows.

When the unit I is adjusted, by rotating the screw 89, say to increase the speed of the strip 4, it increases the speed of differential gear 76 and 63, and the spider 60 rotates and this turns the cam 73 in the direction to reduce the brake action of the brake unit F to allow the strip to have a greater constant speed.

In the absence of other provisions, this increase of strip speed would cause the output shaft 16 of power unit A to increase in speed, and its torque to fall, because of the said torque-speed characteristic. That can then be compensated for, by turning the rheostat 49 to increase the torque as described. For convenience, the contact 51 of rheostat 49 may be connected by a shaft 111 and gears 110—109 to the adjusting screw 89; so that turning the screw 89 to increase the strip speed also adjusts the rheostat 49 to restore the torque or maintain it and maintain the strip tension.

Knowing the speed-torque characteristic of the power unit A, and the change of strip speed for each turn of the screw 89, the ratio of the gears 109—110 and the resistance of the resistor 52 per unit of length is readily predetermined so that rotation of the screw 89 by an increment to increase the strip speed as aforesaid, is accompanied by a concurrent compensating increment of movement of the contact 51 in the torque increasing direction; which results in maintaining the torque without change at the increased strip speed; and the unchanged torque results in unchanged or constant strip tension; and this obtains throughout the winding operation, and throughout the increase of diameter of the coil 80 because the torque is always applied tangentially to the coil.

If now it be desired to change the strip tension at any adjusted strip speed, without changing the speed, the rheostat 50 is adjusted by rotating the contact 54 in one direction or the other, which, as explained above, due to the torque-speed characteristic, changes the torque of the output shaft 16.

If, for example, the torque of the shaft 16 be increased in this manner, it tends momentarily to increase the speed of the strip 4; but any increase of strip speed will increase the speed of the roll 9, shaft 12 and differential gear 62. Differential gear 63 is running at a fixed speed determined by adjustment of the unit I; so that now the spider 60 is rotated by the difference of speed of the gears 62 and 63 and operates the cam 73 to increase the braking action at the unit F, until the differential gear 62 is rotating again at the same speed as the fixed speed gear 63, whereby the strip speed is maintained without change but now at increased tension.

Thus, in general, by adjusting the unit I at the push button contactors 104 and 105 to speed up or slow down the strip, the strip speed can be adjusted to any desired speed, and for all strip speeds, the strip tension will remain constant; but the strip tension can be adjusted at any speed by the rheostat 50.

A wide range of strip speed adjustment is provided by the unit G, because the speed of the differential gear 77 can be changed to any speed from zero to a high speed by adjustment of the speed ratio of the belt pulleys 89—81 through a practical range of only 4 to 1.

A wide range of tensions is also provided by the rheostat 50.

In Fig. 2 is illustrated, another means, or modification, for braking or resisting rotation of the supply coil 3 for the described purposes.

Two differential gearings indicated generally at J and K constitute a transmission, and are part of a braking unit indicated generally at M.

The gearing J comprises a spider element 112 rotatably supporting pinions 113—113 meshed with differential gears, 114—115. The gearing K

comprises a spider element 116 rotatably supporting pinions 117—117 meshed with differential gears 118—119. The spider elements 112—116 have peripheral teeth meshed at 120. The gears 114 and 118 are connected respectively to gears 121 and 122, both meshed with a gear 123 connected to the shaft 2 of the strip supply drum 1.

The gears 115 and 119 are connected respectively to units 124—125 constructed like direct current generators or motors and at this point the unit 124 will be considered as a generator, and the unit 125 as a motor. The generator 124 has a closed local series load circuit connected to its brushes, comprising wires 126—127. The generator 124 may generate current in the load circuit which includes the motor 125 in series to drive it.

The generators 124 and motor 125 have separately excited field windings 128—129 respectively energized from direct current mains 130—131, through a potentiometer type rheostat 132, comprising a resistor 134 and a rotary contact 133. Current from the main 130 goes to the rotary contact 133, and there divides, and part going through one side of a resistor 134 of the rheostat, by wire 135, to the field winding 128, thence by wire 136, to the main 131; and the other part going through the other side of the resistor 134, by wire 137, to the field winding 129, and thence by wire 138, to the main 131. The rotary contact 133 is connected to the spider 60 of gearing E through shaft 139, and gears 67, 66, 64.

For some midpoint of the contact 133, the two fields 128—129 are equal, or balanced, to cause the units 124—125 to develop equal potentials, and at other points the voltage of one is greater than that of the other.

The shaft 12 goes from the roll 9 to the differential gearing E, as it does in Fig. 1 and drives the differential gear 62 thereof as in Fig. 1; the spider 60, and the gears 61 to 67 all being reproduced from Fig. 1.

A motor 140, preferably a squirrel cage induction motor as shown is mechanically connected to the spider 116 by a pinion 141 driven by the motor 140 and meshed with the spider, and is electrically connected to mains 142—142.

In general, unwinding of the strip 4 from the drum 1, rotates it and its shaft 2, and by means of the gearings J—K, the power supplying motor 140 is driven as a generator and supplies power back to the mains 142, and a hold-back load torque or braking action is thereby effected on the shaft 2 and drum 1.

The generator 140 has the construction of a squirrel cage induction motor which could be driven as a motor by alternating current from the mains 142—142; but as is well known when such a motor is mechanically driven above synchronous speed, the curve of torque to drive it rises very steeply, very much the same as the output torque curve rises when it delivers power as a squirrel cage motor and is mechanically loaded to reduce its speed below synchronous speed.

Other types of electric generators, D. C. or A. C. may be employed as the generator 140 but a squirrel cage induction motor type is preferred because of its simplicity and its rapidly rising torque as aforesaid when driven as a generator.

For purposes of explanation it will first be assumed that the fields of the units 124—125 are equally energized by their field windings 128—129 by some midpoint of the rheostat contact 133;

and the drum 1 and shaft 2 are at rest; and that the unit 140 is connected to the mains 142—142 and runs as a motor and drives the two spiders 116—112 in opposite directions.

5 Torque from the spider 112, under these assumed conditions, divides equally between differential gears 114 and 115; and torque from the spider 116 likewise divides equally between differential gears 118—117.

10 This tends to drive the connected pairs of gears 114—121 and 118—122 in opposite directions the same as the spiders 112—116, but the gears 121—122 being both meshed with the gear 123, no rotation occurs; and the units 124—125 are driven in opposite directions, and at twice the speed of the spiders, 112—116.

15 The units 124—125 having equal fields, under these assumed conditions, their output potentials are equal and opposite, and no load current flows in the load circuit 126—127 and no torque is developed at the units 124—125.

All torques in the transmission, under these assumed conditions, are negligibly small, and the motor 140 will run at substantially synchronous speed.

25 If now the rheostat contact 133 be moved counterclockwise as viewed in Fig. 2, to a position at the left of said midposition, at which the field winding 129 of unit 125 will be energized more strongly than the winding 128 of unit 124, the unit 125 will act as a generator and generate current in the circuit 126—127 and drive the unit 124 as a motor.

30 Torque is required to drive the loaded generator 125 and is taken from the power driven spider 116 driving the gear 119, and an equal torque consequently is developed on the gear 118 and its connected gear 122, the latter applying its torque to the gear 123, shaft 2, and roll 1, and in the direction to drive the roll in the forward or unwinding direction, or clockwise as viewed in Fig. 2.

The generated load current going to the motor 124 drives it as a motor and its developed torque on the gear 115 reacts on the spider 112 and develops an equal torque on the gear 114 and its connected gear 121, the latter applying its torque to the gear 123, and shaft 2 in the direction to also drive the roll 1 in the forward or clockwise direction of Fig. 1.

40 This forward drive of the roll 1 results as aforesaid from a position for the contact 133 counterclockwise from its midposition; and the contact 133 will be moved to this position as soon as the apparatus is started up because until the roll 1 begins to rotate clockwise the speed-set gear 63 of gearing E will rotate faster than gear 62; and the action of the spider 60 of the gearing E will rotate the contact 133 counterclockwise as will be understood from the description hereinbefore.

45 This counterclockwise rotation of the contact 133 effects more and more driving torque on the roll 1 and coil 3 and the latter rapidly speeds up toward a speed for the strip, at which the speeds of the gears 62 and 63 of gearing E would become equal, and the contact 133 would stop moving counterclockwise.

50 If the contact 133 were to come to a position corresponding to which the roll 1 and coil 3 and strip 4 being wound on the roll 1 would go so fast that the gear 62 at the gearing E (whose speed is controlled by the strip speed) would go faster than the gear 63, the spider 60 would reverse and move the contact 133 clock-

wise and reduce the forward driving torque on the roll and the power driven speed of the roll.

The contact 133 thus tends to come to the mid position at which no driving power would be applied to the roll 1, but does not actually do so because the power unit A winding the strip on the roll 11 constantly tends to cause the gear 62 to go faster than the gear 63 and the contact 133 therefore will always come to a counter-clockwise position, corresponding to a forward power driven speed for the roll 1, at which the tangential speed or strip speed therefrom, is less than the speed of the strip being wound on the roll 11. The strip therefore overhauls the roll 1 and the roll 1 is strip-driven faster than it tends to be power-driven. This causes the mechanism M to exert braking action on the strip and causes tension to be developed in it as follows.

Overhauling the roll 1 and increasing its speed above that produced by the power supplying motor 140, causes the gears 121-114 and the gears 122-118 to be driven in the same direction by the gear 123. The spider 112 is driven oppositely to the spider 116. The spider 116 is driven in the same direction as the gears 121-114 and the spider 112 oppositely to the gears 121-114. Thus the gear 115 and unit 124 will be driven in the same direction as the spider 112.

Thus the spider 112 and the unit 124 will be driven in the same direction, and the unit 124 will act as a generator and drive the unit 125 as a motor.

Torque to drive the generator 124 comes from the gears 121-123 and is supplied by the overhauling roll 1 and tends to retard it, exerting a braking action thereon.

The motor 125 applies torque to the gear 119 to drive it. The gears 122-118 are being driven by the overhauling roll 1. Both gears 119 and 118 therefore react on the spider 116 to overdrive it in the same direction it is being driven, and this drives the motor 140 above synchronism and it becomes a generator supplying current back into the line 142. The torque to thus overdrive the motor 140 comes from the motor 125 and from the gear 122, and the torque of the latter comes from the roll 1 and tends to retard it and also exerts a braking action thereon.

Braking action by the unit M as a whole is thus developed by power driving the roll 1 at a relatively low speed but overhauling by the strip at a higher speed, against the opposition of the transmission and against the driving of the power motor 140 as a generator.

As aforesaid, upon starting up the apparatus, the coil 3 is power-driven to accelerate it and bring it up to the speed of operation. This is one of the particular advantages of the invention in another aspect.

In some cases, the roll 1 and the coil 3 thereon may be of very great weight and inertia; and it would be undesirable to subject the strip to the tension that would be produced thereon by the winding unit A to start and accelerate the roll 1. By the operation above described in connection with the braking action of the unit M, the roll 1 is power driven to start and accelerate it, and the greater its inertia, and the more slowly it tends to accelerate, the greater the accelerating power applied to it.

With either braking mechanism, that at F, Fig. 1, or that at M, Fig. 2, as the coil 3 becomes of smaller radius due to unwinding, tension in the strip would increase if the regulated braking

torque remained at a fixed value; but such increase of strip tension will tend to slow down the strip as described for Fig. 1, and this will adjust the braking action to a smaller amount as described, so that changes of strip tension due to decrease of diameter of the unwinding coil 3 are automatically prevented.

Changes of diameter of winding coil 80 as winding goes on has no effect because it is driven at its circumference as described.

In the foregoing the invention has been described as winding strip material as it comes from a supply wound on a drum; and braking mechanism, in the operation of the invention, acts on the drum. There are cases in which it is desirable to wind strip material coming from sources of strip supply other than a wound drum; and to exert braking action thereon as aforesaid.

In Fig. 3 is illustrated, fragmentarily, one such modification of the invention.

The strip 4 as at 4A comes from any source or supply of strip; and on its way to the above described tier of rolls 5-7-9 of Fig. 1 is gripped by a similar or like tier of rolls 143-144-145.

The strip 4 is drawn through the rolls as it is wound on the drum 11 by the mechanism of Fig. 1 and drives the roll 145 in the same manner as it drives the roll 9 as described.

The shaft 2 is connected at one end to the roll 145 and driven thereby; and at the other end has differential connections with either the braking unit F of Fig. 1 or the braking unit M of Fig. 2, as described for the shaft 2 of those figures.

The shaft 12 driven by the roll 9 is connected through the gear 62 to the parts described in Fig. 1.

Braking action is exerted on the shaft 2 and roll 145; whereby winding the strip on the drum 11 develops strip tension; and the operation otherwise is the same as that of Fig. 1 or Fig. 2.

As to the power supplying motors 21 and 92 of Fig. 1; and the motor 140 of Fig. 2 when braking is to be done by the unit M; they will in general be started and brought up to full speed all at the same time in which event the respective supply wires to the motors may all be connected to a common supply of current through a well known common motor starting contactor or apparatus, not shown.

However the motors have been shown as having separate current supply conductors as indicating that starting contactors or other starting apparatus may be provided individually for each motor and the motors therefore started and brought up to speed at different times if desired.

I claim:

1. A strip material winding apparatus, comprising; a winding drum adapted to be driven by power to wind strip material thereon; a rotary element arranged to be rotated by the strip as it is being wound; brake mechanism braking rotation of the rotary element; mechanism responsive to the linear speed of the strip as it is being wound and controlling the brake mechanism to increase the braking action upon an increase of strip speed and to decrease it upon a decrease of strip speed.

2. A strip material winding mechanism comprising; a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; a rotary element arranged to be rotated by the strip being wound; brake mechanism braking rotation of the rotary element, whereby said torque produces tension in

the strip; mechanism responsive to changes of linear speed of the strip above or below a predetermined value as it is being wound, and controlling the brake mechanism to respectively increase and decrease the braking action upon a tendency for the strip speed to increase or decrease above or below said predetermined value, effective to maintain the strip speed at said predetermined value.

3. A strip material winding mechanism comprising: a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; a rotary element arranged to be rotated by the strip being wound; brake mechanism braking rotation of the rotary element, whereby said torque produces tension in the strip; mechanism responsive to changes of linear speed of the strip above or below a predetermined value as it is being wound, and controlling the brake mechanism to respectively increase and decrease the braking action upon a tendency for the strip speed to increase or decrease above or below said predetermined value, effective to maintain the strip speed at said predetermined value; the mechanism comprising adjusting means to adjust the predetermined value of speed to which it responds; and adjusting means to adjust the torque of the power unit to cause it to maintain constant tension in the strip at all predetermined speed values.

4. A strip material winding mechanism comprising: a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; a rotary element arranged to be rotated by the strip being wound; brake mechanism braking rotation of the rotary element, whereby said torque produces tension in the strip; mechanism responsive to changes of linear speed of the strip above or below a predetermined value as it is being wound, and controlling the brake mechanism to respectively increase and decrease the braking action upon a tendency for the strip speed to increase or decrease above or below said predetermined value, effective to maintain the strip speed at said predetermined value; the mechanism comprising adjusting means to adjust the predetermined value of speed to which it responds; and adjusting means to adjust the torque of the power unit to cause it to maintain constant tension in the strip at all predetermined speed values; and a connection between the two adjusting means for effecting an adjustment of the torque concurrently with an adjustment of the predetermined speed value.

5. A strip material winding mechanism comprising a winding drum for winding strip material in a coil thereon; a power unit applying torque to the periphery of the coil to wind the strip material; brake mechanism braking movement of the strip toward the drum, whereby the said torque produces tension in the strip; automatic speed responsive apparatus causing the braking action to vary in response to tendency of strip speed to change, effective to maintain the strip speed constant; the power unit comprising means to cause the drum-applied torque to be constant, at constant drum speed effected by said constant strip speed, to maintain the strip tension constant.

6. A strip material winding mechanism comprising a winding drum, for winding strip material in a coil thereon; a power unit applying torque to the periphery of the coil to wind the strip material; brake mechanism braking move-

ment of the strip toward the drum, whereby the said torque produces tension in the strip; speed responsive apparatus causing the braking action to vary in response to tendency of the strip speed to change, effective to maintain the strip speed constant, and means to adjust the speed responsive apparatus to change the constant speed; the power unit comprising means to cause the drum applied torque to be constant at constant strip speeds, and comprising means to adjust the constant torque.

7. A strip material winding apparatus comprising: a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; a rotary element arranged to be driven by movement of the strip material toward the drum; brake mechanism braking rotation of the rotary element; a speed reference unit having a rotary output element rotating at a fixed speed; a differential gearing comprising three gearing elements; one element driven by the output element of the speed reference unit; means driving another element at speed proportional to the strip linear speed; and rotation of the third element controlling the effectiveness of the brake mechanism.

8. A strip material winding mechanism comprising a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; brake mechanism braking movement of the strip toward the drum whereby said torque produces tension in the strip; a speed reference unit having a rotary output element rotating at a fixed speed, and an adjustment means to adjust the fixed speed; a strip-driven rotary element driven by linear movement of the strip toward the drum, at speed proportional to strip speed; a control for varying the effectiveness of the brake mechanism responsive to the difference of speed of the speed reference output element and the strip driven element; the power unit comprising electric winding means, the degree of energization of which controls the value of said torque applied to the drum; adjustment means for adjusting the energization of the winding means; interconnection means between the adjustment means of the speed reference unit and the adjustment means of the winding means, whereby a change of adjustment of one effects a concurrent change of adjustment of the other.

9. A strip material winding mechanism comprising a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; brake mechanism braking movement of the strip toward the drum whereby said torque produces tension in the strip; a speed reference unit having a rotary output element rotating at a fixed speed, and an adjustment means to adjust the fixed speed; a strip-driven rotary element driven by linear movement of the strip toward the drum, at speed proportional to strip speed; a control for varying the effectiveness of the brake mechanism responsive to the difference of speed of the speed reference output element and the strip driven element; the power unit comprising electric winding means, the degree of energization of which controls the value of said torque applied to the drum; adjustment means for adjusting the energization of the winding means; interconnection means between the adjustment means of the speed reference unit and the adjustment means of the winding means, whereby a change of adjustment of one effects a concurrent change of adjustment of the other; and a second adjustment means for changing

the energization of the winding means, independently of the said interconnected adjustment means.

10. A strip winding apparatus comprising: a winding drum; a power unit applying torque to the drum to drive it to wind strip material thereon; a rotary element rotated by the strip being wound; brake mechanism braking rotation of the rotary element; whereby said applied torque produces tension in the strip; a strip-driven element rotatably driven by the linear movement of the strip toward the drum at rotary speed proportional to the strip linear speed; a power driven speed reference mechanism having a rotary output element adjustable to different selected fixed rotary speeds; means controlling the braking effect of the brake mechanism responsive to the difference of rotary speeds of the strip-driven element and the speed reference output element.

11. A strip material winding apparatus comprising a power supplying unit, applying torque to a winding drum to wind a coil of strip material thereon, and constructed to deliver different values of constant torque at different constant speeds, and comprising means to adjust the constant torque value at any constant speed; braking apparatus braking movement of the strip toward the winding drum whereby torque applied to the drum produces tension in the strip; strip speed responsive apparatus causing the braking action to increase and decrease in accordance with tendency of the strip speed to increase and decrease to maintain the strip speed constant, and comprising adjusting means to adjust the constant strip speed.

12. A strip material winding apparatus comprising a power supplying unit, applying torque to a winding drum to wind a coil of strip material thereon, and constructed to deliver different values of constant torque at different constant speeds, and comprising means to adjust the constant torque value at any constant speed; braking apparatus braking movement of the strip toward the winding drum whereby torque applied to the drum produces tension in the strip; strip speed responsive apparatus causing the braking action to increase and decrease in accordance with tendency of the strip speed to increase and decrease to maintain the strip speed constant, and comprising adjusting means to adjust the constant strip speed; the power unit arranged to apply the winding torque to the periphery of the coil being wound on the drum; whereby the apparatus winds the strip at adjustable constant speed and adjustable constant tension.

13. An apparatus for winding strip material in a first rotatably supported coil and unwinding it from a second rotatably supported coil, comprising: a motor driven transmission having a rotary output element arranged to apply winding torque to the outer periphery of the first coil; the transmission having a torque-speed characteristic according to which the torque applied by its output element decreases with increase of its speed and vice versa; brake mechanism for variably braking unwinding rotation of the second

coil whereby torque on the first coil produces tension in the strip; a power driven speed reference mechanism having a rotary speed element and adjusting means to adjust the speed of the speed element and maintain it at constant selected fixed speeds; a speed responsive rotary element and means to rotate it at speeds corresponding to the linear speed of the strip; alternately rotatable means for increasing and decreasing the braking effect of the brake mechanism and driven differentially by the speeds of the said speed element and the said speed responsive element; and the transmission comprising means for adjustably varying the torque of its output element.

14. The apparatus described in claim 13 and in which the brake mechanism comprises a brake drum driven by the second coil and a brake shoe frictionally engaged therewith, and mechanism interconnecting the brake shoe and the alternately rotatable means, effective to alternately increase and decrease the engagement friction, responsive to alternate rotary movements of the alternately rotatable means.

15. The apparatus described in claim 13 and in which the brake mechanism comprises a power driven braking transmission having a rotary output element, arranged to apply retarding torque to the second coil to yieldingly oppose unwinding rotation thereof; and the braking transmission comprises means responsive to alternate movements of the alternately rotatable means effective to increase and decrease the retarding torque.

16. In a strip material winding apparatus, a winding drum driven by a first constantly running motor through a first transmission to wind strip on the drum, the first transmission being responsive to apply first motor torque to the drum that decreases as the drum speed increases and vice versa; a first rotary element and a second rotary element each constrained to rotate at a speed corresponding to the speed of the strip toward the drum; a second motor of an electric type that can be overdriven and develop electric load in a supply line connected thereto, connected to the first rotary element through a second transmission; a speed responsive mechanism operated by the second rotary element; the second transmission arranged to apply electric motor torque to the first rotary element in the strip moving direction to accelerate it when the strip starts to move; and the second transmission being responsive to the speed responsive mechanism to tend to drive the first rotary element at speed less than the speed of the strip when the strip is moving toward the winding drum; to cause the first rotary element to be overdriven by the strip; and the second transmission then being responsive to drive the electric motor as a generator; to cause the first rotary element to be retarded and exert braking action on the strip; whereby tension is developed in the strip by the winding drum driving motor and first transmission.

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No references cited.