

Dec. 7, 1965

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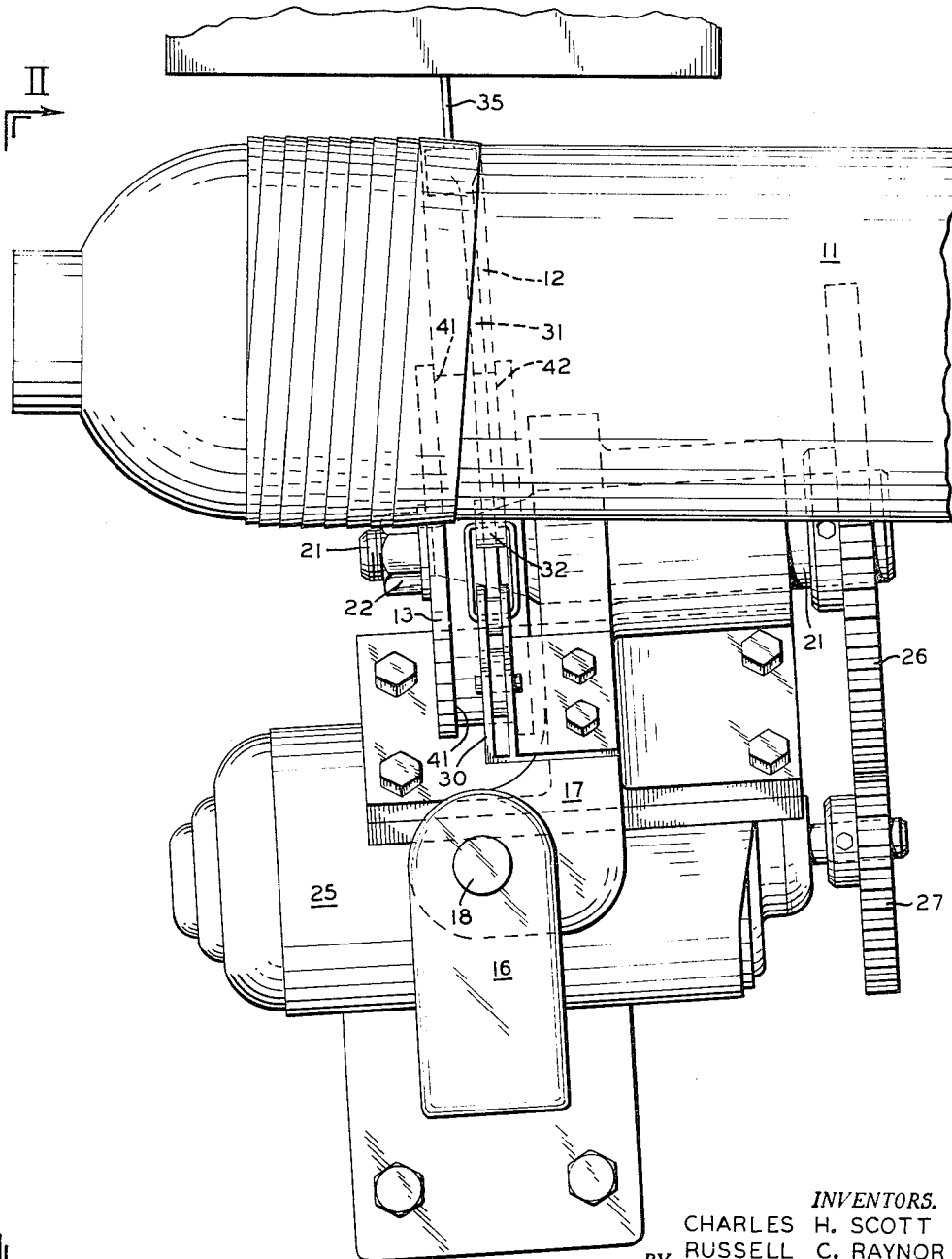
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STRIP TENSIONER

Filed June 28, 1961

5 Sheets-Sheet 1

FIG. 1



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5 Sheets-Sheet 2

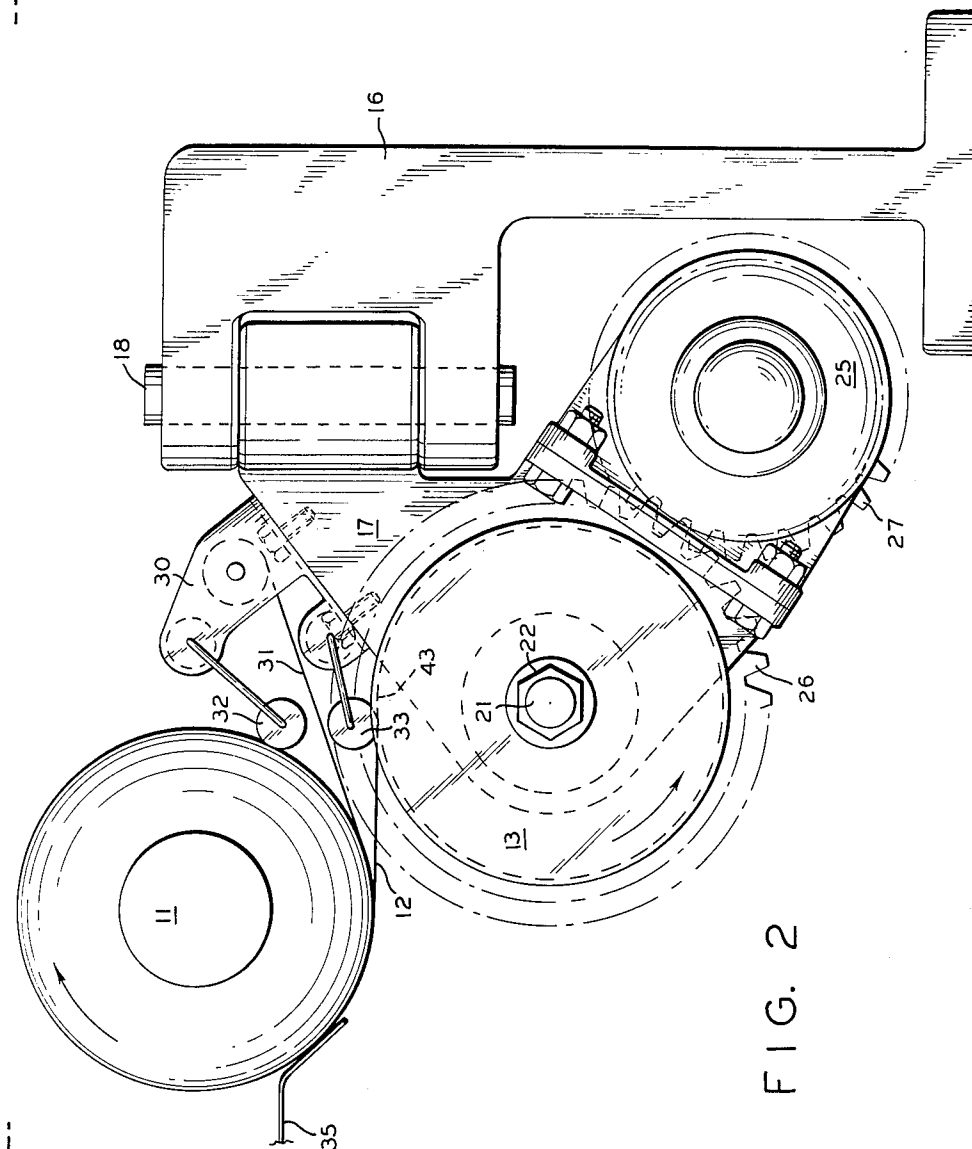
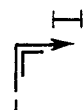


FIG. 2

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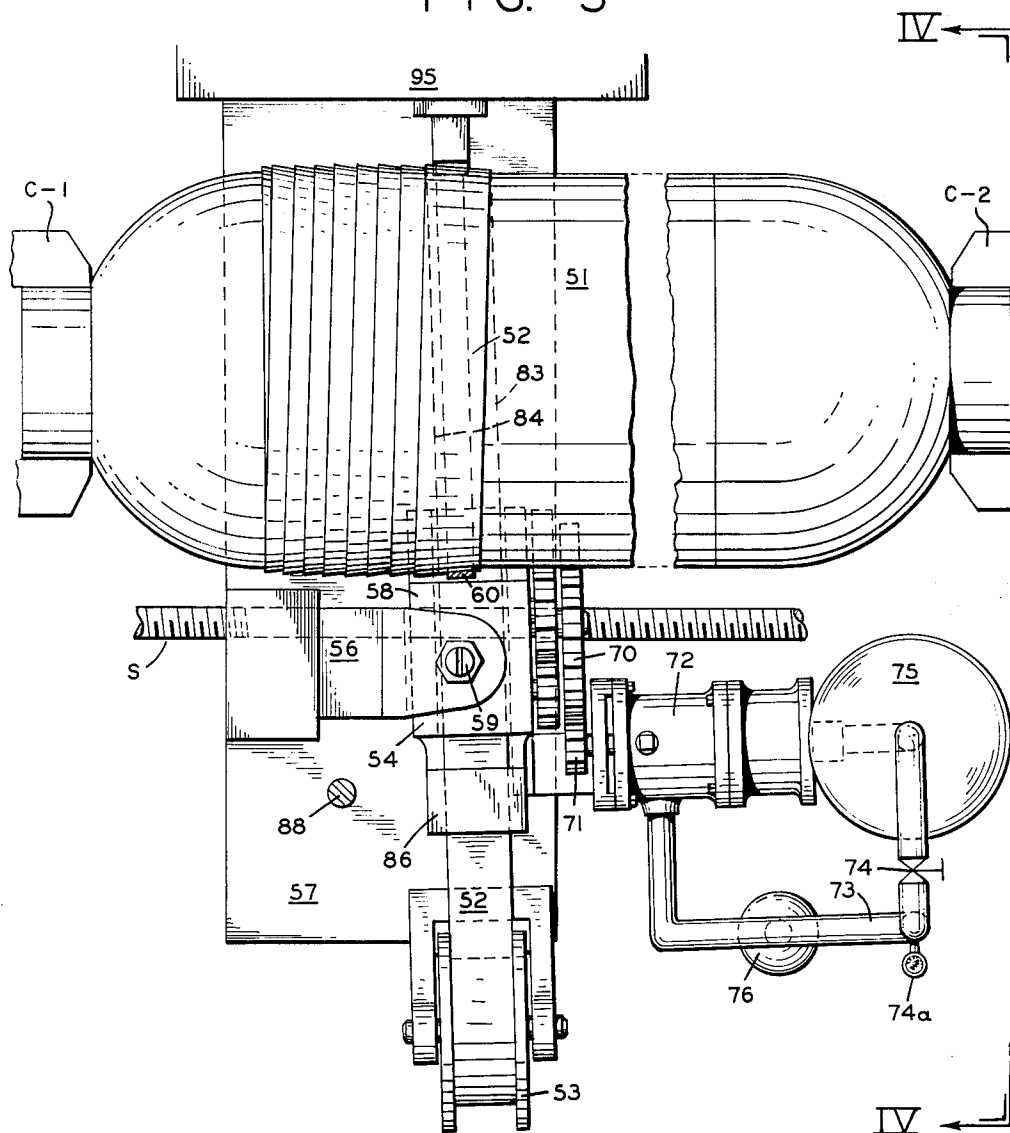
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STRIP TENSIONER

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5 Sheets-Sheet 3

FIG. 3



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1

3,221,401

STRIP TENSIONER

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17 Claims. (Cl. 29—203)

This application is a continuation-in-part of copending U.S. patent application Serial No. 41,934 filed July 11, 1960, by Scott and Raynor, now abandoned.

This invention relates to apparatus for helically winding strip material. More particularly, this invention relates to a carrier assembly for supporting apparatus for feeding under tension the strip material which is to be wound in a helical fashion around a mandrel.

This invention finds particular utility in connection with the preparation of pressure containing vessels wherein a different tension is applied to each of the lengthwise edges of the strip being wound around the mandrel.

It is an object of this invention to provide a tensioner for strip material which will automatically provide for the proper stress distribution in the strip material to provide this differential tension across the width of the strip.

It is a further object of this invention to provide such apparatus which provides the proper stress differential automatically and continuously.

These objects and other objects and advantages of this structure which will become apparent as this specification proceeds are achieved by the interposition of a freely pivotable connection between the locus of application of the tension-producing dragging force to the strip material and the main support for the device producing such drag.

Illustrative of specific embodiments of this invention are the accompanying drawings in which:

FIG. 1 is a schematic plan view of one embodiment of the invention as viewed from line I—I of FIG. 2;

FIG. 2 is a schematic elevational view of the embodiment of FIG. 1 as seen from line II—II of FIG. 1;

FIG. 3 is a schematic plan view of another embodiment of the invention with parts omitted for clarity;

FIG. 4 is a schematic elevational view of the embodiment of FIG. 3 as seen from line IV—IV of FIG. 3; and

FIG. 5 is an enlarged elevational view of a portion of FIGURE 4.

Referring next to the drawings, and more particularly to FIGURES 1 and 2, there is illustrated a mandrel 11 adapted to be rotated by means of a lathe chuck, not shown, and upon which the pressure containing vessel is to be constructed by the helical wrapping of strip material 12 which is fed from a reel 13 carried by a device which is one embodiment of this invention.

The carrier for the reel of strip material according to this invention comprises essentially (a) a main support 16 which is adapted to be mounted on a lathe carriage, not shown, for longitudinal movement parallel to the axis of the mandrel 11 at a speed coordinated with the rotational speed of mandrel 11 imparted by the lathe chuck, not shown, to provide the appropriate helix angle for the pressure containing vessel to be constructed, and (b) a reel support 17 for supporting a reel of strip material during the winding operation, with (c) a freely pivotable connection interconnecting the main support 16 and the reel support 17 for permitting free rotation of the reel support 17 relative to the main support 16 about the

2

axis of pivot 18. As will be explained later, the orientation and location of the axis of pivot 18 with respect to the edges of the strip 12 leaving reel 13 is important for determining the stress distribution imparted to strip 12 during the winding operation.

Reel 13 is mounted on reel support 17 on rotatable axle 21 and is held in place by nut 22. Since it is desired to pull strip material 12 from reel 13 under tension, means is provided for braking the rotation of reel 13 on axle 21. In the specific means illustrated herein, such braking means includes a dynamometer 25 which is mounted on reel support 17 and which is provided with suitable conventional means for controlling the torque of the dynamometer brake 25. An example of a comparable dynamometric device or dynamometer is shown in U.S. patent to Merritt No. 2,947,494. Since the dynamometer will normally operate best at a somewhat higher rotational speed than the rotational speed imparted to axle 21 by the withdrawal from reel 13 to strip 12, a pair of speed increasing gears 26, 27 are affixed to axle 21 and to the rotor of dynamometer 25 (through an integral gear box coupled to the dynamometer) so as to permit dynamometer 25 to operate at a higher rotational speed than reel 13 and to mechanically interconnect them so that braking action applied to dynamometer 25 serves to retard the motion of reel 13.

Of course, any other conventional braking mechanism may be mounted on reel support 17 and applied so as to retard the rotary motion of reel 13 so as to produce the desired braking effect. Illustrative of such other types of braking mechanism might be mentioned a hydraulic pump pumping against a pressure relief valve, the work of pumping serving for braking reel 13; a Prony brake applied to axle 21 to retard the rotation of reel 13; or an automotive type brake applied to axle 21.

In order to produce a constant tension during the unwinding of strip 12 from reel 13, the amount of braking force applied must be varied continuously. With the dynamometer type brake illustrated here, the compensation of the braking force with change in radius of strip 12 on reel 13 inherently occurs. With other types of conventional brake mechanisms, compensators may be incorporated to vary the braking force to maintain constant tension on strip 12 leaving reel 13 as the radius decreases.

The overlapping portions of the strip material forming the pressure containing vessel are brazed to each other. In order to provide for the brazing operation, reel support 17 may be provided with a braze carrier 30 for supporting a roll of braze material 31 which is fed between the layers of strip material 12 on mandrel 11. Also supported on reel support 17 are a pair of flux applicators 32, 33 which apply flux to opposite sides of strip 12 for promoting the subsequent brazing operation. Mounted upon the lathe support carriage, not shown, to follow along with the motion of the main support 16 is a heater 35 which serves to fuse the braze 31 thereby bonding the laps of strip 12 to each other progressively during the winding operation.

As was mentioned before, the location of free pivot 18 interconnecting reel support 17 and main support 16 relative to the planes defined by the edges of strip 12 wrapped on reel 13 is important for it determines the distribution of stress in the strip being wound around mandrel 11.

As is best seen from FIGURE 1, the edges of strip 12 wrapped on reel 13 define two planes, a left plane 41 and a right plane 42. It will be noted that the axis of free pivot 18 is located intermediate planes 41 and 42 and is parallel to such planes.

As is best seen in FIG. 2, strip 12 is withdrawn by the rotation of mandrel 11 from reel 13 at a point 43 on the circumference of strip 12 wound on reel 13. Point 43 may be considered the locus of application of the tension-producing dragging force to strip 12, such force being exerted by dynamometer brake 25 acting on reel 13. It will be noted that the axis of free pivot 18 is substantially perpendicular to a plane tangent to strip 12 on reel 13 at point 43. It is also to be noted that the axis of free pivot 18 is located to intersect the plane which is tangent to strip 12 on reel 13 at point 43 between planes 41 and 42 on the side of point 43 opposed to the direction of withdrawal of strip 12 from reel 13. This spacing of the axis of pivot 18 behind point 43 is made rather small and is to produce an effect similar to a caster.

The opposite edges of strip 12 are subjected to different tensions during the operation of winding around mandrel 11. The difference in tensions between the high tension side of strip 12 and the low tension side of strip 12 is determined from the diameter and total thickness of the pressure containing vessel being produced and the width of strip 12 between planes 41 and 42. In order to minimize the total tension applied to strip 12, it is desirable to have the low tension side of strip 12 have a tension as close to zero as possible during the winding.

In order to prevent slippage of strip 12 around reel 13 during the winding operation under the tension produced by the pull of mandrel 11 and the drag of the braking means such as the dynamometer 25, the strip is wound around reel 13 under a tension which is substantially the average of the tensions to be used in the winding operation around mandrel 11. This average pretension is incorporated during the manufacture of strip 12, particularly during the step of winding strip 12 onto reel 13.

The location of the axis of pivot 18 between planes 41 and 42 redistributes this tension previously incorporated in strip 12.

If the desired stress distribution were such as to produce substantially equal tensions on all portions of strip 12, the axis of pivot 18 would be substantially centrally located between planes 41 and 42. Where other stress distributions are desired, pivot point 18 will be displaced from such central location to an eccentric location between planes 41 and 42, such displacement being toward the plane of the edge of the strip which is to receive the higher tension. As specifically illustrated in FIG. 1, the axis of pivot 18 has been displaced toward plane 41 so as to be approximately one-third of the distance from plane 41 to plane 42. This location produces a stress distribution which is substantially triangular, i.e., the edge of strip 12 at plane 41 receives a maximum tension and the other edge at plane 42 receives substantially zero tension. The absolute magnitude of the tension on strip 12 at plane 41 is controllable through the expedient of varying the drag on reel 13 imparted by the braking action of dynamometer 25. For still other stress distributions other locations of the axis of pivot 18 may be chosen.

Referring next to FIGS. 3, 4 and 5, there is illustrated another embodiment of this invention in which a mandrel 51 adapted to be rotated by means of lathe chucks C-1 and C-2, is utilized and upon which the pressure containing vessel is to be constructed by the helical wrapping of strip material 52 fed from a reel 53 through a tensioning device 54 which is pivotably mounted in accordance with the teaching of this invention. Reel 53 is rotatably supported in support bracket 55 on lathe carriage 57 by means of axle 50.

The tensioning device according to this invention comprises essentially (a) a main support 56 which is adapted to be mounted on a lathe carriage 57 for longitudinal movement parallel to the axis of mandrel 51 at a speed coordinated with the rotational speed of mandrel 51 imparted by the lathe chucks, to provide the appropriate helix angle for the pressure containing vessel to be con-

structed, and (b) a tensioning device 54 through which strip 52 passes over a plurality of rollers to retard the passage of strip 52, with (c) a freely pivotable connection interconnecting the main support 56 and the housing 58 of tensioning device 54 for permitting free rotation of the tensioning device 54 relative to the main support 56 about the axis of pivot 59. In the same manner as was explained in connection with the embodiment of FIGS. 1 and 2, the orientation and location of the axis of pivot 59 with respect to the edges of the strip 52 passing through and leaving tensioning device 54 is important for determining the stress distribution imparted to strip 52 during the winding operation. The carriage 57 is movable on a pair of parallel tracks T-1 and T-2, and is moved by a screw spindle S.

Tensioning device 54 comprises a housing 58 having a top wall 61, a bottom wall 62, and a pair of side walls 63. A plurality of rollers 64 are supported for rotation between side walls 63 by means of axles 65, which axles extend through one of said side walls 63 for a distance sufficient to have keyed thereto intermeshing gears 68. It will be noted that because of the intermeshing of identical gears 68, all of the rollers 64 will turn simultaneously at the same rotational speed as each other.

One of the axles 65 extends through and is keyed to a larger gear 70 which meshes with a gear 71 which, as is best seen in FIGS. 3 and 4, operates to drive a piston pump 72 to provide a braking force acting on rollers 64 to retard the free rotation thereof. Piston pump 72 provides this braking force by pumping a fluid, such as oil, through conduit 73 past a constriction, such as valve 74, to reservoir 75 from which the fluid is recirculated to pump 72. In order to even out the fluctuations in pressure produced by piston pump 72, conduit 73 is provided with a pressure accumulator 76 which includes a hollow chamber provided with a flexible diaphragm 77 which serves to entrap a compressible fluid, such as a gas, in chamber 78. The braking force applied to rollers 64 is controlled by adjusting the size of the opening in constriction valve 74 to produce the desired back pressure on pump 72 as measured by pressure gauge 74a. Control of this braking force controls the magnitude of the tension applied to strip material 52 by tensioning device 54.

Strip material 52 enters tensioning device 54 and is trained over and around each of the plurality of rollers 64 in a meandering or serpentine fashion and is pulled from tensioning device 54 by the rotation of mandrel 51. In order to provide for accurate lateral positioning of strip material 52 on rollers 64 as it passes therearound, the first roller 64 (uppermost roller 64 as illustrated in FIGURE 5) is provided with edge flanges 64a which accurately guide strip material 52. However, because the rollers 64 are not permitted to turn freely but must turn under the retarding influence produced by the interaction of constriction valve 74 and pump 72, a tension is imparted to strip 52. Enough rollers 64 are used so that strip 52, when pulled through tensioning device 54, will not slip or slide past the rollers, but will cause rollers 64 to turn against this controllable retarding force to ensure proper control of the amount of tension produced in strip 52.

Mounted within the upper wall 61 and the lower wall 62 of housing 58 are ball-bearings 81 into which pivots 59 mounted in main support 56 are inserted. In this fashion, tensioning device 54 is mounted in main support 56 for freely pivotable movement by the use of pivots 59 and ball-bearings 81.

As is best seen in FIGS. 3 and 5, strip material 52 having edges 83 and 84 is passed through tensioning device 54. Pivot 59 is mounted substantially perpendicular to the plane of strip 52 leaving the last pulley 64 at point 85 (which may be considered the locus of application of the tension-producing dragging force to strip 52) and is located eccentrically with respect to the edges of strip

52. More particularly, in making a pressure containing vessel as explained above in connection with the embodiment of FIGS. 1 and 2, pivot 59 is displaced toward edge 84 of strip 52 so as to have its axis be approximately one-third of the distance from edge 84 to edge 83. This location produces the same stress distribution as was produced by the same location in the previous embodiment.

It is apparent from the above explanation, that the tension distribution is controlled by the location of the axis of pivot 59 with respect to the edges 83 and 84 of strip material 52 and that the absolute magnitude of the tension imparted to strip 52 is controllable through the expedient of varying the size of the constricted opening in valve 74.

Since the reel 53 of strip material 52 is mounted on lathe carriage 57 in a fixed orientation by bracket 55, and since tensioning device 54 is mounted for pivotable movement in support 56, it has been found desirable to provide housing 58 with a guide 86 to ensure that strip 52 is accurately fed onto the first roller 64 between edge flanges 64a regardless of the slight misalignments caused by the free pivoting movement of tensioning device 54 on the eccentrically located pivot 59.

Tensioning device 54 provides the tension to strip material 52 by multiplying the tension already on the strip as it passes over each roller 64 operating against the retarding force of the braking mechanism. Because of this, it is important that strip material 52 approaching the first roller 64 have some tension already applied to it. This pretensioning may very desirably be applied by guide 86 exerting a controlled drag on strip material 52. A comparable pre-tensioning device is shown in U.S. patent to Revel No. 2,251,205. In a particular installation wherein strip material 52 was steel strip and rollers 64 were approximately one inch diameter steel rollers, it was found necessary to apply at least about six pounds of pretension to strip material 52 approaching the first roller 64 from guide 86 to ensure a constant tension of about three hundred pounds tension in strip material 52 leaving the last roller 64.

As is best seen in FIG. 4, lathe carriage 57 is provided with a support 88 on which a plurality of elements are mounted for supplying fluxed braze into the nip produced by the helical wrapping of strip material 52 about mandrel 51. These elements include generally a reel 89 of strip braze 90 mounted for rotation for withdrawal of strip braze 90 therefrom, brake means 91 for retarding the rotation of reel 89 when strip braze 90 is withdrawn therefrom, flux coating device 92, flux dryer 93, and guide 94, all supported in the appropriate positions on support post 88. Also mounted on lathe carriage 57 for movement therewith, is a heater 95 which serves to fuse the braze 90 thereby bonding the laps of strip 52 to each other progressively during the winding operation.

It will thus be seen that herein has been provided a tensioner, as exemplified in the embodiment of FIGS. 1 and 2 and the embodiment of FIGS. 3, 4 and 5, for strip material which is adapted to provide a controllable tension having a proper stress distribution across the width of the strip of material as it is being withdrawn from the tensioner, and to provide this stress differential automatically and continuously.

As is readily apparent, the apparatus of this invention need not necessarily be mounted on a lathe carriage for longitudinal movement coordinated with rotary motion of a mandrel as described above. It could also be mounted for combined longitudinal and orbital movement around a stationary mandrel to wrap strip about the mandrel.

While two specific embodiments of this invention have been illustrated and described, it is not intended that the definition of this invention be limited to the specific details shown and described, but is to encompass all equivalents fairly encompassed within the scope of the subjoined claims.

We claim:

1. A strip winding arrangement comprising a cylindrical mandrel turnable about its horizontal axis with power means for rotating the same, a carriage movable parallel to the axis of said mandrel at a predetermined rate of speed relative to a speed at which the mandrel is rotated, a reel carrying a supply of the strip material and moving along with said carriage, and a strip tensioning device operatively interposed between said reel and said mandrel, from which the strip material is to be drawn under tension by said mandrel, and which comprises a main support mounted on said carriage, a swivel frame structure, pivotal means connecting said swivel frame structure with said main support structure and extending substantially at right angles to the axis of the mandrel, a rotary member mounted for rotation on said swivel frame structure for delivering said strip material from said reel to said mandrel so that the material is wound thereon with the windings overlapping one another, and with the pivotal axis of the swivel frame located in a plane extending intermediate and parallel to the planes defining the edges of the strip material on said rotary member, which intermediate plane is located closer to the trailing side edge than to the leading side edge of said material, and a dynamometric device comprising a turnable element positively driven from said rotary member and adapted to convert rotation imparted thereto by said rotary member into another form of energy, with means settable for varying a torque load on said turnable element and with means for indicating the amount of said load, whereby the tension of said strip material at the point of application thereof to the mandrel is controllable by the setting of said settable means in accordance with the load indications, the location of said swivel axis being effective by the relative stretch imparted to the trailing side edge of the strip to accommodate the strip windings in overlapping relationship with one another.

2. A tensioning device from which strip material is to be withdrawn under tension which comprises,

a main support structure,

a swivel frame structure, pivotal means connecting said swivel frame structure with said main support structure,

a sequence of at least two parallel guide rollers rotatably mounted on said swivel frame with their axes extending transversely of said pivotal axis and arranged so as to provide a meandering course for said strip material when in frictional engagement with said rollers, and furthermore arranged relative to said pivotal axis so as to establish equilibrium for said swivel structure when said strip is under tension, said pivotal axis being located in a plane intermediate and substantially parallel to the planes including the respective lateral edges of the strip material frictionally engaged by said rollers,

a gear coaxially connected to each roller, said gears meshing with one another to rotate simultaneously due to the withdrawal of the strip material frictionally engaged by said rollers,

a brake device carried by said swivel frame and effective to apply initial tension to the strip material at least sufficient to establish frictional non-sliding contact between said strip and said rollers while the strip is being drawn through the tensioning device against torque load resistance imposed upon said rollers,

and dynamometric means driven by one of said guide rollers, having controllable torque load means resisting the rotation of said guide roller, whereby the torque load as well as the strip tension diminishes from each roller to the next preceding roller, while providing the required withdrawal tension in said strip.

3. The tensioning device according to claim 2, wherein said dynamometric means is driven by the terminal guide

roller located at the delivery end of said meandering course.

4. The tensioning device according to claim 2, wherein said dynamometric device comprises pump means driven by said guide roller, fluid receiver means for said pump means, and adjustable flow throttling means at the delivery side of the pump means, the pump means operating in circuit with said receiver means.

5. The tensioning device according to claim 2, wherein said intermediate plane containing the pivotal axis is closer to one of said parallel planes than to the other, such location of said swivel axis being effective by the relative stretch imparted to the trailing side edge portion of the strip to accommodate the strip windings in overlapping relationship with one another.

6. The tensioning device according to claim 2, wherein said intermediate plane containing the pivotal axis is spaced from one edge of the strip a distance of about one third of the width of the strip, such location of said swivel axis being effective by the relative stretch imparted to the trailing side edge portion of the strip to accommodate the strip windings in overlapping relationship with one another.

7. The tensioning device according to claim 2, with guide means for edgewise guiding said strip material at the feed end of said meandering course.

8. The tensioning device according to claim 2, wherein said sequence of guide rollers comprises a terminal guide roller at the delivery end of said meandering course, a first preceding guide roller geared to said terminal roller and delivering the strip material thereto, a second preceding guide roller delivering the strip material to said first preceding guide roller, and a third preceding guide roller delivering the strip material to the second preceding guide roller and having gear meshing engagement with said terminal guide roller as well as with said second preceding guide roller.

9. The tensioning device according to claim 2, wherein said sequence of guide rollers comprises six guide rollers, and wherein the terminal guide roller has gear meshing engagement with the first preceding guide roller, wherein the terminal guide roller also has gear meshing engagement with the third preceding guide roller, while the second preceding guide roller has gear meshing engagement solely with the third preceding guide roller, and wherein the fourth preceding guide roller has gear meshing arrangement with the third preceding guide roller as well as with the fifth preceding guide roller.

10. The tensioning device according to claim 2, wherein said sequence of guide rollers comprises a plurality of pairs of guide rollers.

11. The tensioning device according to claim 2, wherein said swivel frame structure comprises a pair of side walls, and end walls rigidly interconnecting said side walls, and wherein said guide rollers are mounted for rotation in said side walls, each of said end walls having pivotal connections with said main support structure.

12. The tensioning device according to claim 2, wherein said swivel frame structure comprises a pair of side walls, end walls rigidly interconnecting said side walls to constitute therewith a boxlike structure, wherein said main support structure comprises a bracket member located at one side of said boxlike structure and having pivotal connection with each of said end walls thereof, and wherein said dynamometric device is mounted upon the opposite side of said boxlike structure and bodily movable therewith.

13. The tensioning device according to claim 2, wherein said dynamometric means comprises a pump driven by said guide roller to operate against a controllable resistance.

14. The tensioning device according to claim 2, wherein said swivel frame structure comprises a pair of side walls, end walls rigidly interconnecting said side walls to constitute therewith a boxlike structure,

wherein said main support structure comprises a bracket member located at one side of said boxlike structure and having pivotal connections with the respective end walls thereof,

and wherein said gears and said dynamometric device are mounted at the opposite side of said boxlike structure.

15. A tensioning device from which strip material is to be withdrawn under tension, which comprises

a main support structure,

a swivel frame structure, pivotal means connecting said swivel frame structure with said main support structure

a sequence of parallel guide rollers rotatably mounted on said swivel frame structure with their axes extending transversely of said pivotal axis and arranged so as to provide a meandering course for said strip material when in frictional engagement with said rollers, and furthermore arranged relative to said pivotal axis so as to establish equilibrium for said swivel structure when said strip is under tension, said pivotal axis being located in a plane intermediate and substantially parallel to the planes comprising the respective lateral edges of the strip material frictionally engaged by said rollers, a gear coaxially connected to each roller, said gears meshing with one another to rotate simultaneously due to the withdrawal of the strip material frictionally engaged by said rollers,

a brake device carried by said swivel frame and effective to apply initial tension to the strip material at least sufficient to establish frictional non-sliding contact between said strip and said rollers while the strip is being drawn through the tensioning device against torque load resistance imposed upon said rollers,

and dynamometric means operatively connected to said rollers having controllable torque load means resisting the rotation of said rollers, whereby the strip tension diminishes from each roller to the next preceding roller while providing the required withdrawal tension in the strip.

16. Strip winding apparatus which comprises a collapsible mandrel turnable about its horizontal axis with power means for rotating the same,

a carriage movable parallel to said mandrel axis at a predetermined rate of speed relative to the speed of rotation of the mandrel so that the strip is wound onto the mandrel in overlapping fashion, with the trailing edge portion of each strip winding overlapping the leading edge portion of the preceding winding,

a reel carrying a supply of the strip material and moving along with said carriage,

and a strip tensioning device operatively interposed between said reel and said mandrel, through which the strip is drawn by said mandrel, which device comprises

a main support structure mounted on said carriage,

a swivel frame structure, pivotal means connecting said swivel frame structure with said main support structure,

a sequence of at least two parallel guide rolls rotatably mounted on said swivel frame with their axes extending transversely of said pivotal axis and arranged so as to provide a meandering course for said strip material when in frictional engagement with said rolls, and furthermore arranged relative to said pivotal axis so as to establish equilibrium for said swivel structure when said strip is drawn under tension, said pivotal axis being located in a plane intermediate and substantially parallel to the planes including the respective lateral edges of the strip material frictionally engaged by said rolls, a gear coaxially connected to each roll, said gears

9

meshing with one another to rotate simultaneously due to the withdrawal of the strip material frictionally engaged by said rolls, a brake device carried by said swivel frame and effective to apply initial tension to the strip material at least sufficient to establish frictional non-sliding contact between said strip and said rolls while the strip is being drawn through the tensioning device against torque load resistance imposed upon said rolls, and dynamometric means driven by one of said guide rolls, having controllable torque load means resisting the rotation of said guide roll, whereby the torque load as well as the strip tension diminishes from each roll to the next preceding roll, while providing the required withdrawal tension in said strip.

17. The tensioning device according to claim 2, with guide means for edgewise guiding said strip material at the feed end of said meandering course, comprising a pair of guide flanges provided on the initial guide roll, and with additional guide means for said strip provided on said brake device.

10

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