May 23, 1967 R. L. GASPER ET AL 3,320,874

STRAPPING MACHINE

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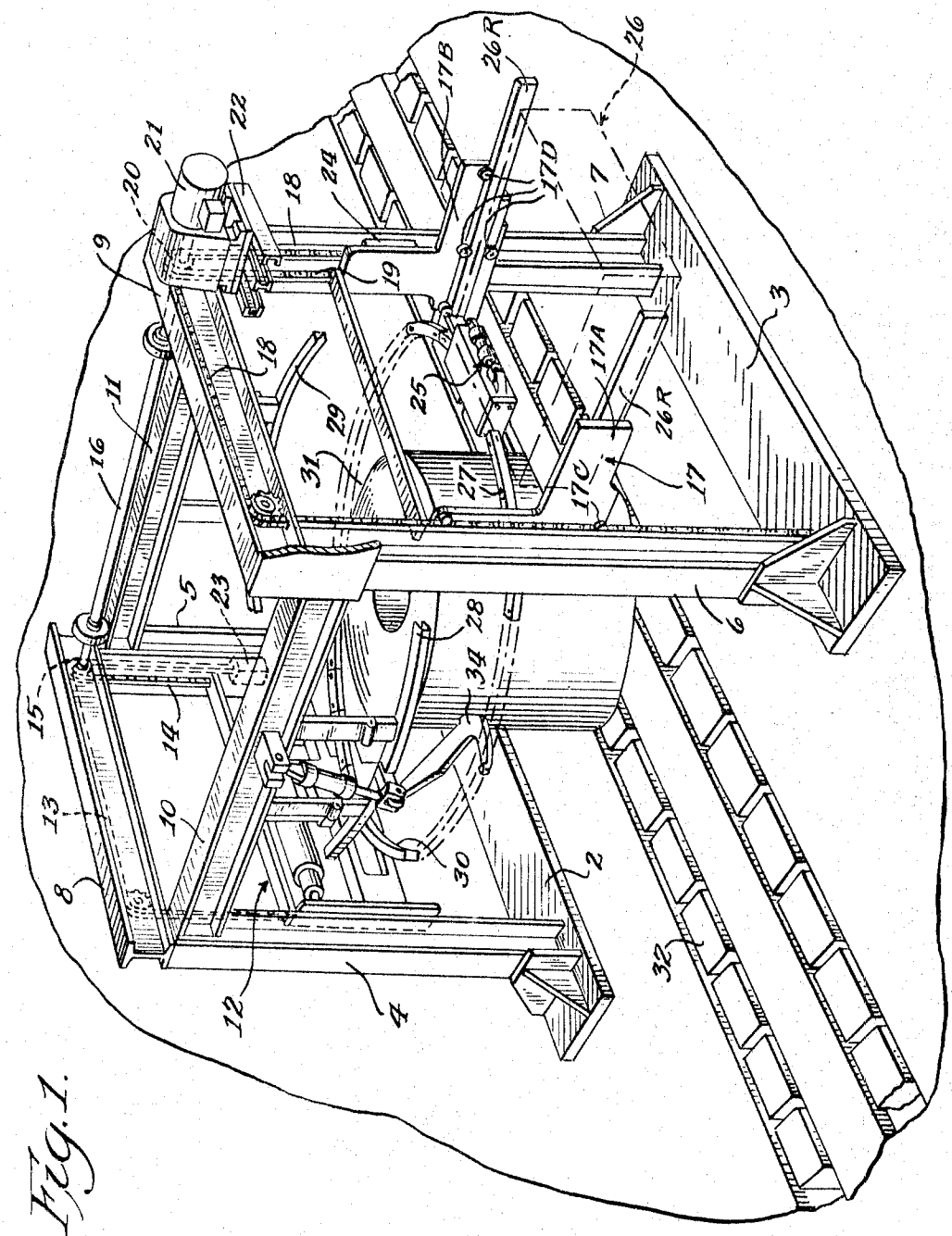


Fig. 1.

Inventors
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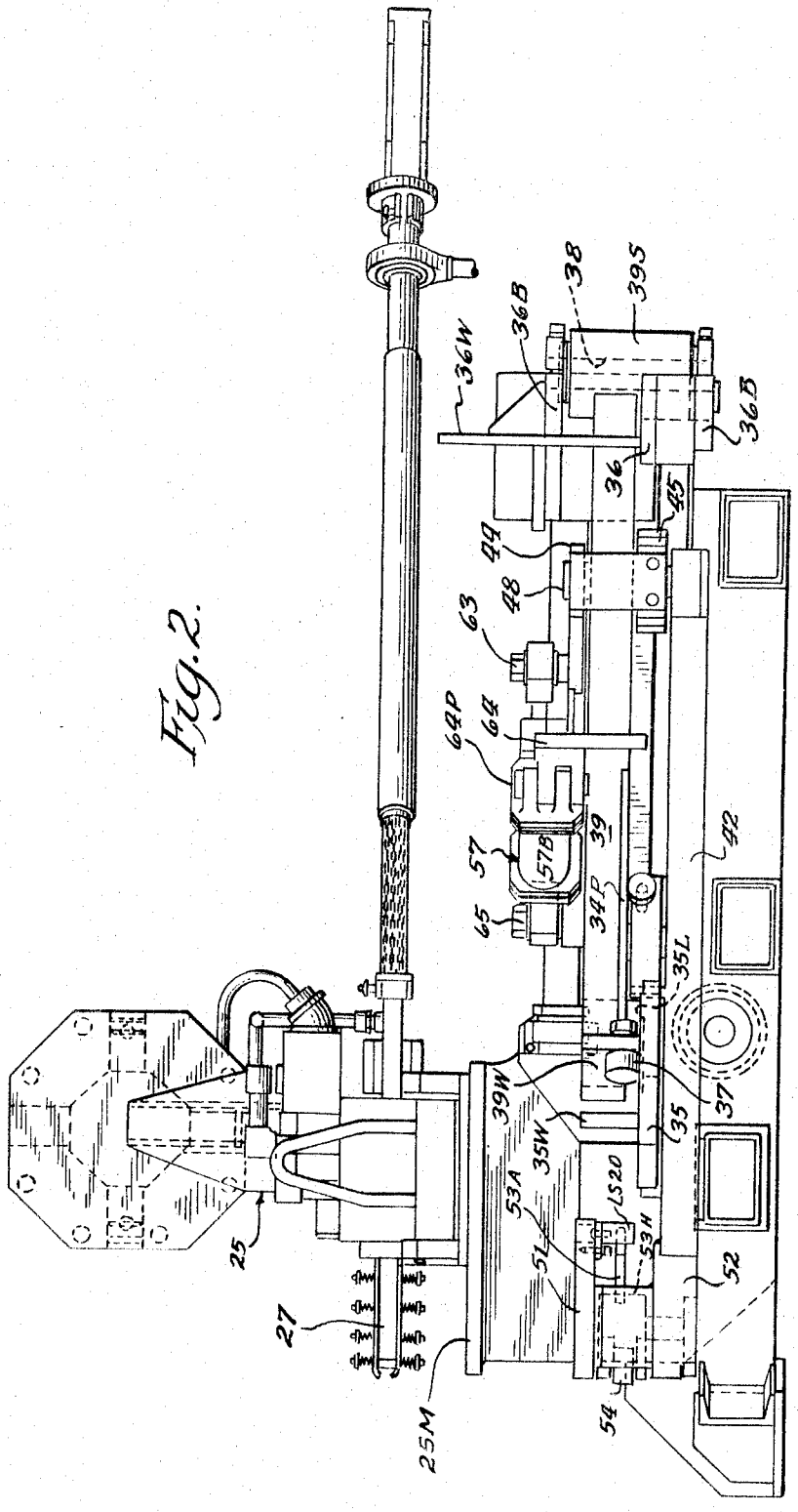
By William P. Porcelli Atty.

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STRAPPING MACHINE

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Fig. 2.



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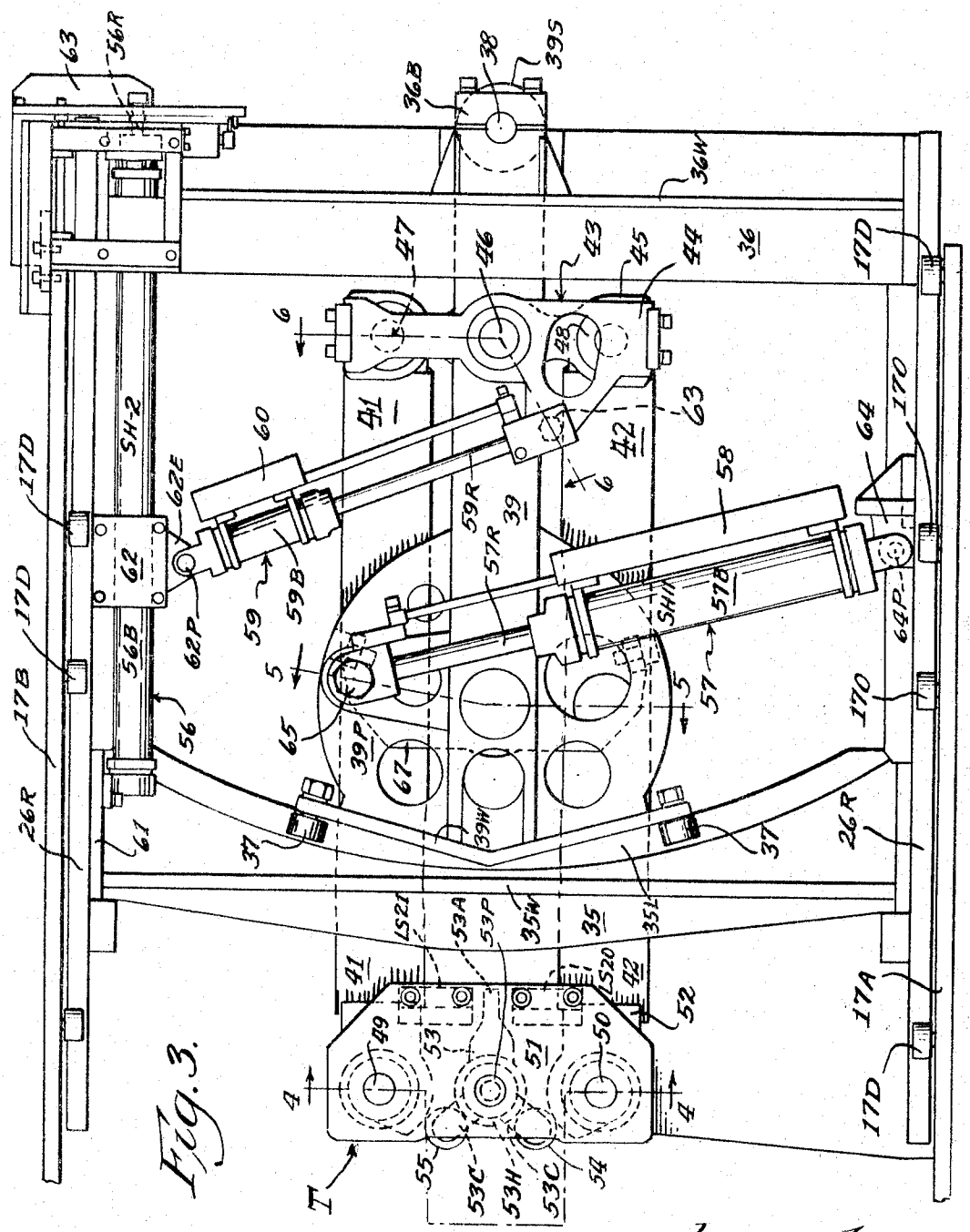


FIG. 3.

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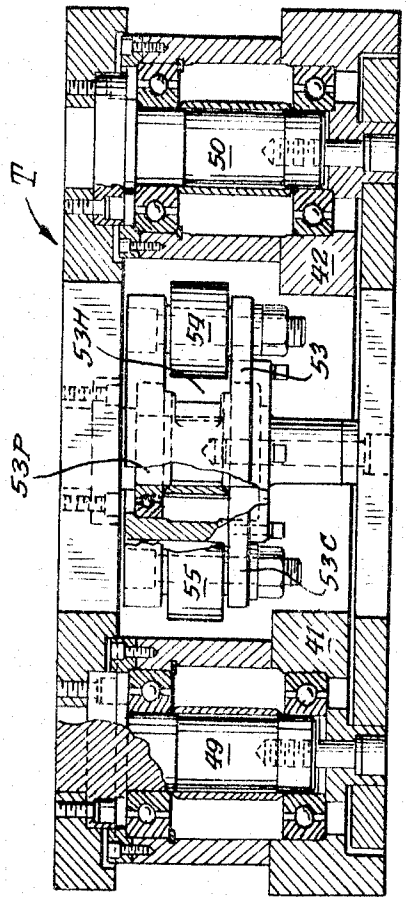


Fig. 4.

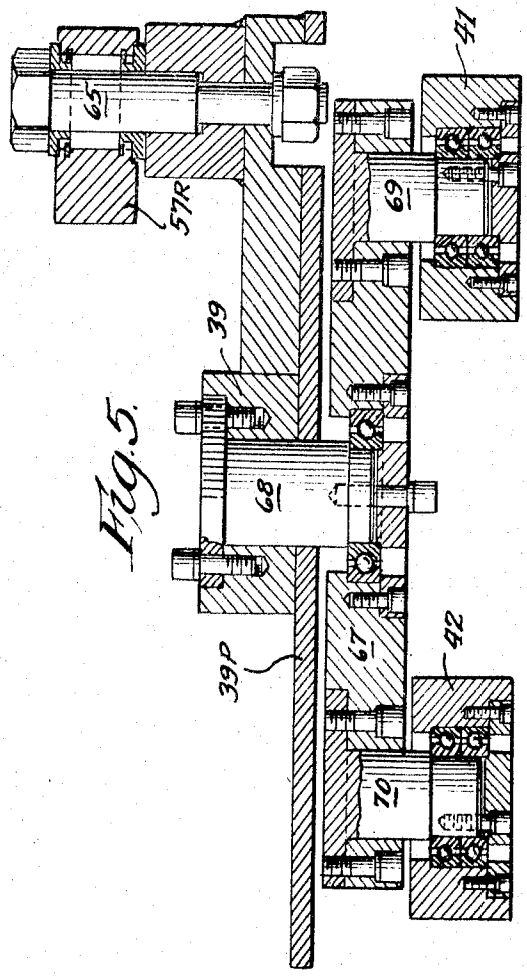


Fig. 5.

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STRAPPING MACHINE

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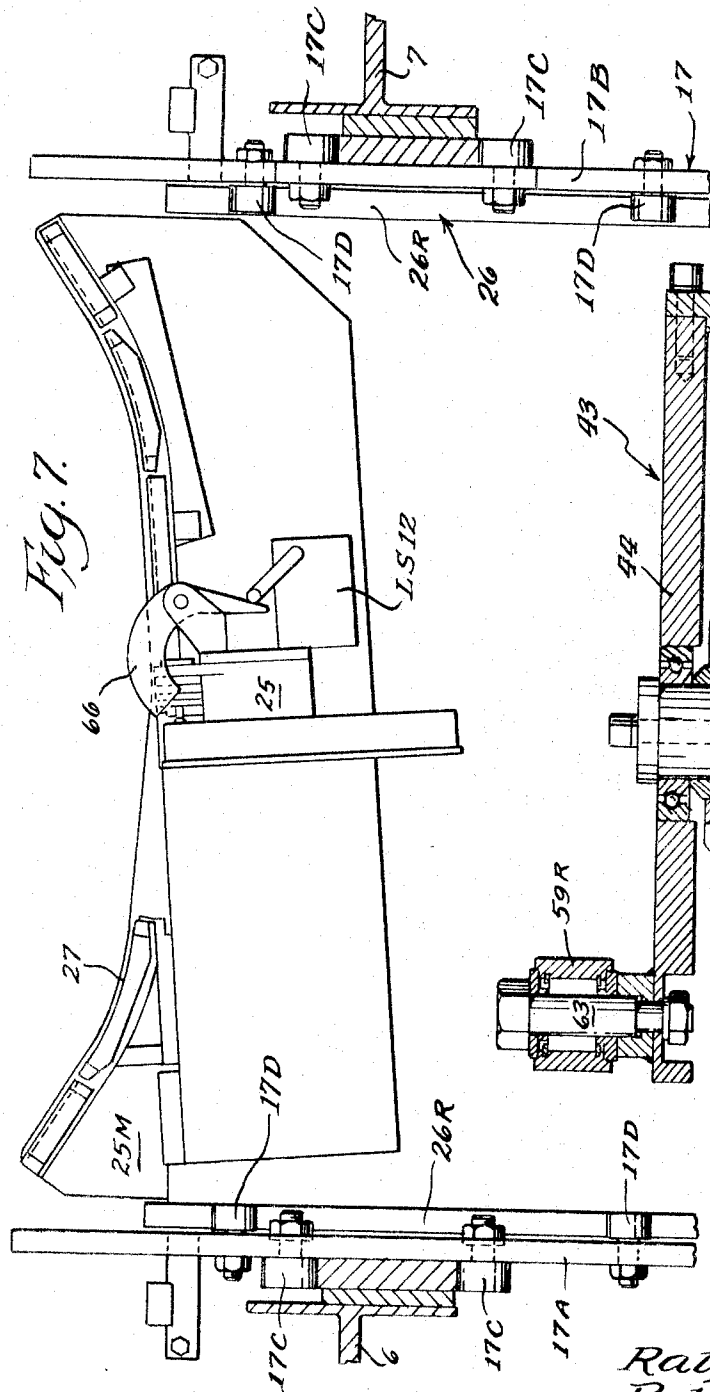


Fig. 7.

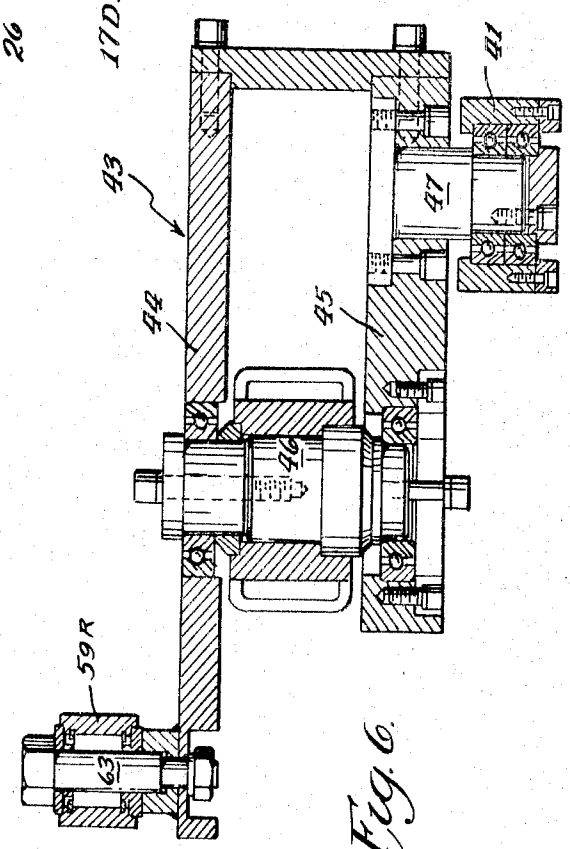


Fig. 6.

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May 23, 1967 R. L. GASPER ET AL 3,320,874

STRAPPING MACHINE

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Fig. 10.

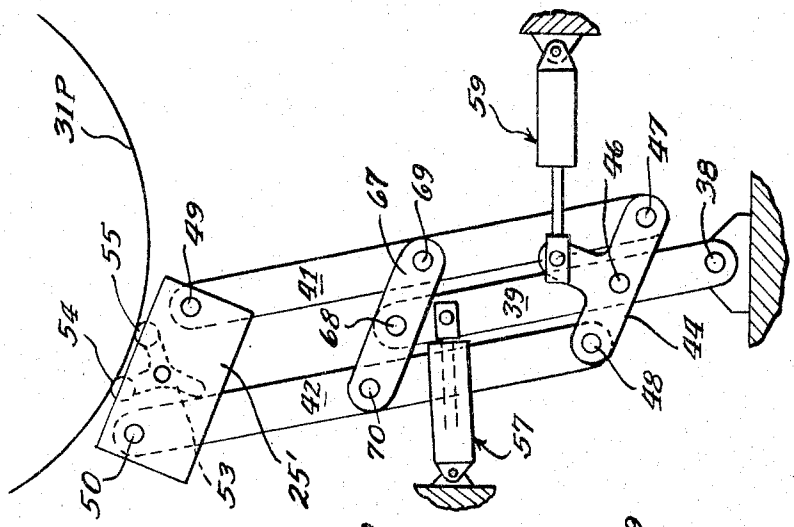


Fig. 9.

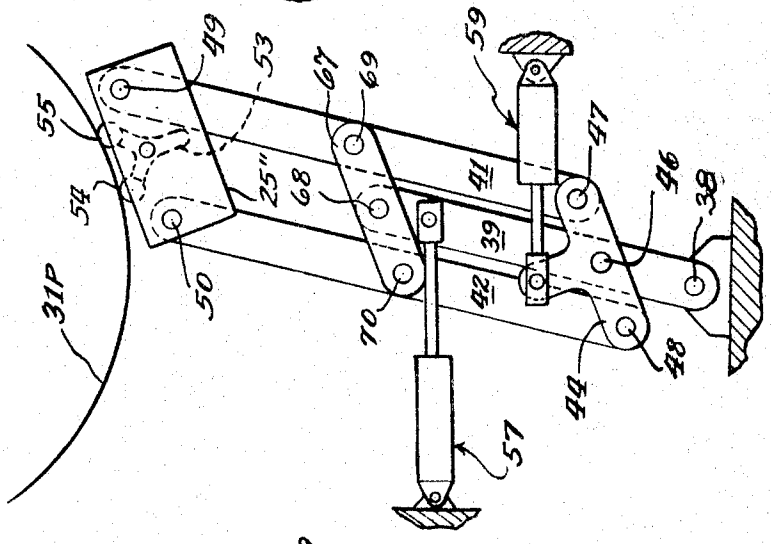
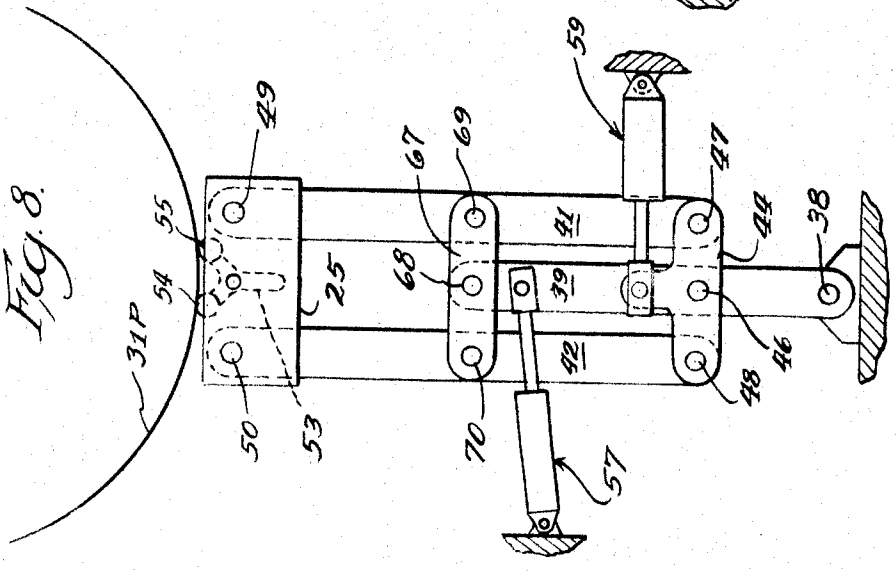


Fig. 8.



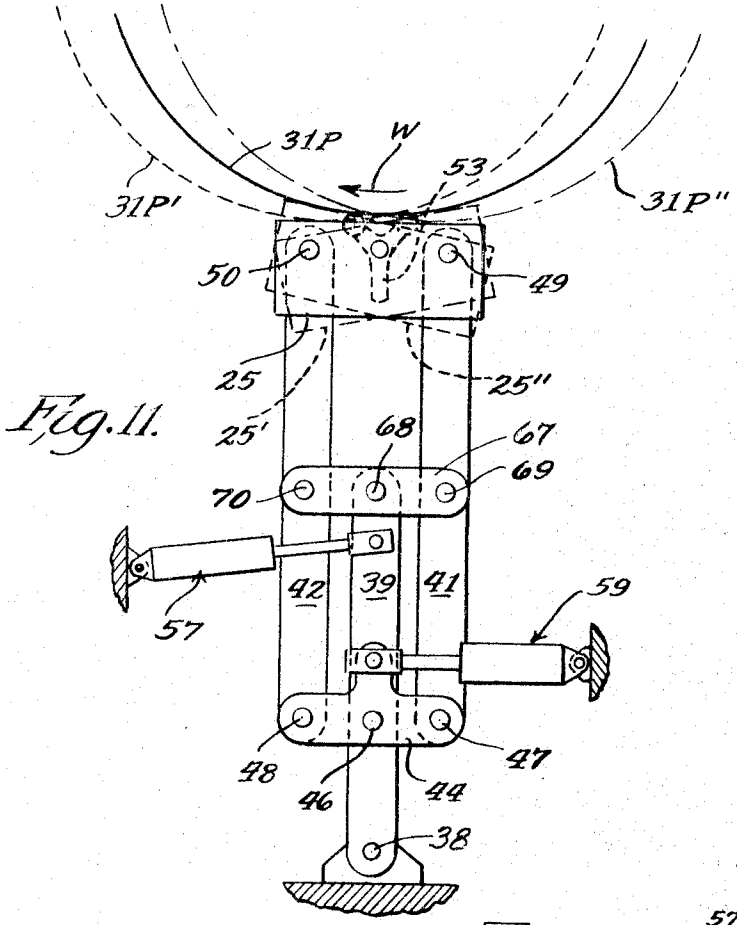

31P
W
53
31P'
31P"
50
49
25
25'
25"
68
67
69
70
57
42
39
41
59
48
46
44
47
38

Fig. 11.

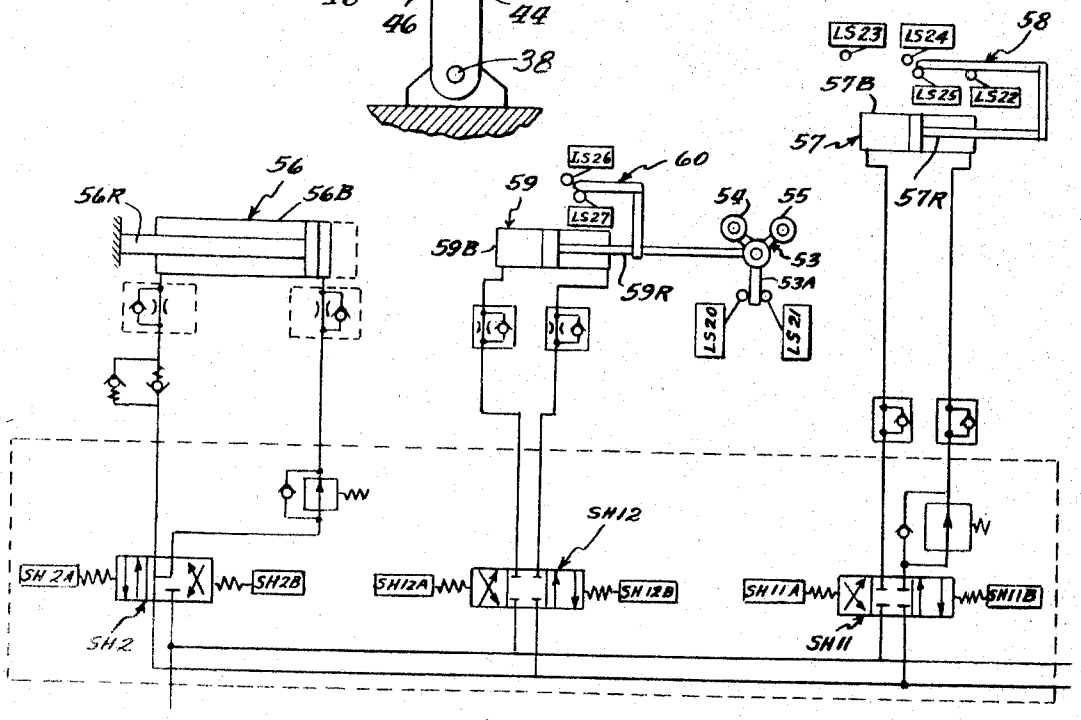
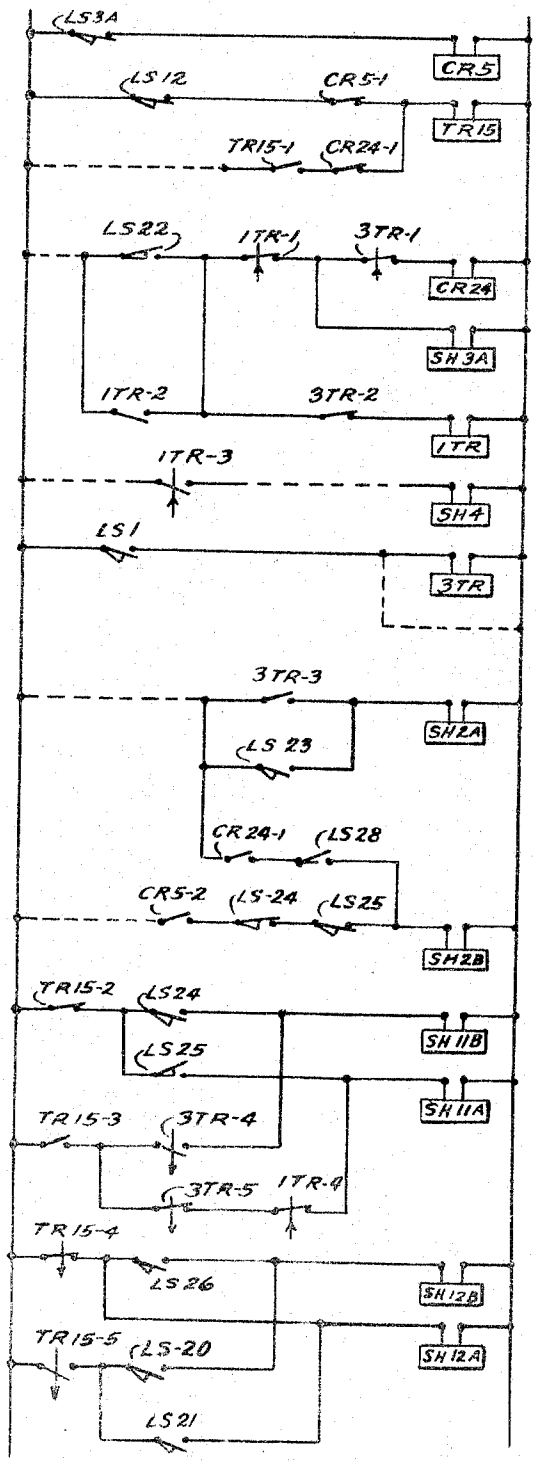

56
56R
56B
LS26
60
59
LS27
59B
59R
54
55
53
53A
LS20
LS21
LS23
LS24
58
57B
LS25
LS22
57
57R
SH12
SH 24
SH2B
SH2
SH12A
SH12B
SH11A
SH11B
SH11

Fig. 12.

STRAPPING MACHINE

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Fig. 13.



United States Patent Office 3,320,874 Patented May 23, 1967

3,320,874

STRAPPING MACHINE

Ralph L. Gasper, Lansing, Robert A. Johnson, Flossmoor, and Robert G. Treptow, Park Forest, Ill., assignors to Interlake Steel, Chicago, Ill., a corporation of New York

Filed Sept. 27, 1965, Ser. No. 490,566
19 Claims. (Cl. 100—3)

This invention relates to the art of tying cylindrical objects with binder straps and particularly relates to strapping apparatus and method for applying binder straps to formed sheet coils.

Formed sheet coils are mass produced in steel plants and as produced consist of a substantially tightly wound, high turn multiple spiral coil. The outer wraps of the coil, however, are loose because of the natural unwinding tendency of any formed sheet coils and the problem is to tighten the loosened outer wraps and apply a strap loop snug on the tightened coil. In the usual steel production operations, these coils are hot when presented for tying at the strapping station. The wrap tightening and coil tying problem is greatly aggravated by the heated condition of the coils.

In production line operations, the coils to be tied are advanced in succession to the strapping station and exact alignment of the coil center line with the strapping head is difficult to assure but is important in facilitating the strapping operation.

Until now, it has been difficult to tie a coil with a strap loop except by tolerating some looseness in the outer wraps of the coil. Arrangements to accomplish wrap before application of the strap loop have been tried, but the installation is greatly complicated and the wrapping equipment is subject to excessive wear and maintenance. Arrangements to insure exact centerline registry are known but the equipment is complicated and expensive.

The principal object of the invention is the provision of improved strapping apparatus for tying a loop of a binder strap about a cylindrical object.

Another object of the invention is the provision of improved strapping apparatus having means for maintaining required tangency between a strapping head and a cylindrical object which is to be tied with a binder strap by the action of the head.

A further important object of the invention is the provision of improved strapping apparatus and method for tying a binder strap loop in tight relation about a formed steel coil.

Still another object of the invention is the provision of novel apparatus and method for wrapping and tying a formed coil by establishing a strap loop snug upon the outer wrap and rotating the loop and outer wrap in a coil wrapping movement to draw the inner wraps taut while taking up strap to shrink the strap loop and outer wrap as the coil shrinks.

The technique of using the strap loop as the coil gripping element during the wrapping action enables direct transition from coil wrapping to strap loop tying and sealing; permits faster total operating time since wrapping and final strap loop tightening occur simultaneously; enables only the particular single use strap loop to take all the wear associated with contacting the hot coil while providing a wrapping action which minimizes marking or damaging of the outer wraps of the coil; avoids strict dependence upon exact registry of the coil centerline and the strapping head; and permits the strapping head and its support structure also to apply the wrapping force, thus obviating necessity of other powered devices for performing the wrap function. Another object of

the invention is to provide a strapping apparatus and method exhibiting these advantages.

A further specific object of the invention is the provision of strapping apparatus having positioning linkage for powering a strapping head through an arcuate wrapping path while maintaining tangency of the strapping head to the coil periphery.

Another object of the invention is the provision of a strapping apparatus for final wrapping and tying of coils on a production line, with the apparatus being functional for wrapping in opposite directions to enable ease of adaptation to any type of production line.

Still a further object of the invention is the provision of strapping apparatus and method particularly suited to wrapping and tying a hot formed coil by establishing a strap loop snug on the coil an slowly rotating the loop to wrap the coil while adjusting loop size, with the loop expansion due to thermal effects being automatically compensated.

Other and further objects of the present invention will be apparent from the following description and claims, and are illustrated in the accompanying drawings which show structure embodying preferred features of the present invention and the principles thereof, and what is now considered to be the best mode in which to apply these principles.

In the accompanying drawings forming a part of this specification, and in which like numerals are employed to designate like parts throughout the same;

FIG. 1 is a perspective view of a strapping station of a type used in conjunction with a production line for hot formed steel coils, the station being equipped with a strapping head mounting and positioning system in accordance with the present invention;

FIG. 2 is a side elevational view of the strapping head and positioning system;

FIG. 3 is a plan view of the positioning system structure of FIG. 2;

FIGS. 4, 5, and 6 are fragmentary sectional views taken as indicated by the lines 4—4, 5—5, and 6—6, respectively, on FIG. 3;

FIG. 7 is a plan view of a strapping head and a strap guide segment;

FIGS. 8, 9, and 10 are diagrammatic plan views of the positioning system of FIG. 3;

FIG. 11 is another diagrammatic plan view of the positioning system;

FIG. 12 is a hydraulic circuit diagram; and

FIG. 13 is an electric circuit diagram.

The invention is described in association with a production line of formed hot steel coils and the strapping station may have the general arrangement shown in Winkler Patent No. 3,252,408, issued May 24, 1966.

The principal features of the strapping station are described here to provide proper environment for understanding the operation of the strapping system of this invent but it should be understood that the present system has application apart from the specific arrangements shown herein.

The strapping machine **1** in which the invention is shown embodied consists of two bases **2** and **3**; the base **2** supports two corner posts **4** and **5** while the base **3** supports two corner posts **6** and **7**. An I-beam **8** is connected between the upper ends of the two posts **4** and **5** while another I-beam **9** is connected across the upper ends of the two posts **6** and **7**. Mounted between the posts **4** and **6** at the upper ends is another I-beam **10**. Similarly mounted between the posts **5** and **7** at their upper ends is another I-beam **11**. The carriage **12** is mounted for vertical movement between the posts **4** and **5** and is supported by two chains **13** and **14** which are driven by means of

sprockets at 15 attached to a shaft 16. Likewise, a carriage 17 is mounted for vertical movement between the two posts 6 and 7 and supported by means of two chains 18 and 19 driven by means of two sprockets at 20 secured to the shaft 16. The shaft 16 is driven in one direction or the other by means of a motor 21 suitably mounted on a platform 22 secured to the post 7.

The chains 13 and 14 are connected at their opposite ends to a counterweight 23 which is guided along the post 5. In a similar manner, the opposite ends of the chains 18 and 19 are secured to another counterweight 24 guided along the corner post 7. With this arrangement, rotation of the shaft 16 by the motor 21 in one direction causes both carriages 12 and 17 to be lowered together while rotation of the shaft 16 by the motor 21 in the opposite direction causes both carriages 12 and 17 to be elevated.

The carriage 17 supports a strapping head 25 mounted on a horizontal slide carriage 26 which is mounted for movement toward and away from the object to be strapped on the two end plates 17*a* and 17*b* of the carriage 17. The strapping head 25 can be of many types, but one particularly suited for such a structure is shown in United States Letters Patent No. 3,120,171, which issued on Feb. 4, 1964, in the names of Sidney V. Hettinger, Jr., and Marchand B. Hall. Such a strapping head automatically feeds a length of strap from a supply source (not shown), permits the length of strap to be encircled into a strap loop, automatically shrinks the strap loop onto an object, and secures the overlapping ends of the strap loop together and severs the strap loop from the supply source.

A strap guide segment 27 carried on the strapping head 25 is positioned vertically by movement of the carriage 17 and a corresponding strap guide segment 30 is positioned vertically by movement of the carriage 12. The carriages 12 and 17 move in synchronism between an upper position wherein the strap guide segments 27 and 30 are in a common horizontal plane with strap guide segments 28 and 29 and a lower position which is pictured in FIG. 1.

When the carriages are in their upper position, adjacent ends of the guide segments 27, 28, 29, and 30 are aligned and cooperably define a generally circular continuous path guideway beginning and ending at the strapping head 25. The strapping head 25 is operable to feed strap through this guideway to form a closed loop or strap S at this elevated position.

The object to be strapped, which is here represented as a hot formed steel coil 31, may be advanced to the strapping station on a horizontal conveyor 32 while the carriages 12 and 17 are at their upper position and the strapping head 25 is forming a closed loop or strap. The coil 31 is brought to a position of approximate registry at the strapping station to be within and below the peripheral outline of the strap loop.

When the coil is in proper position, the carriages 12 and 17 descend to lower the loop of strap S to the position illustrated in FIG. 1 to encircle a midheight region of the coil. The guide segments 27, 28, 29 and 30 are preferably constructed and operated as described in the aforesaid Winkler Patent No. 3,252,408. Thus, before the carriages are lowered to cause the strap guide segments 27 and 30 to also be lowered, the strap guide segments 28 and 29 must be clear of the loop of strap S. Then as the loop of strap is tightened and shrunk onto the coil 31, it must be free to pull out from the confines of the strap guide segments 27 and 30. During this action, progressively less support is provided from the guide members 27 and 30. To prevent drooping of the loop of strap and consequent improper location on the coil, a pair of strap support arms 34 (only one of which is shown) are pivoted to the carriage to swing in a horizontal plane and contact portions of the coil during shrinkage of the loop of strap. Concurrently, the strapping head 25 is moved towards the coil and is guided by and mounted on the horizontal slide carriage 26 in a fashion to generate and apply a wrapping action on the coil.

The structural details of the horizontal slide carriage 26 are shown in FIGS. 2 to 7 and the principles and features of its action in facilitating wrapping of a hot formed steel coil that may have loose outer wraps are diagrammed in FIGS. 8, 9, and 10. The adaptability of the arrangement to compensate for lack of registry of the coil as delivered on the conveyor 32 is illustrated in the diagram of FIG. 11.

It is useful to describe the general principles of the invention for effecting a tight wrapping of the coil 31. This is accomplished by moving the strapping head 25 through a prescribed path and maintaining a prescribed orientation with respect to the coil periphery 31P. The operation of the strapping head 25 is controlled in relation to its travel path to draw the strap loop snug on the outer wrap of the coil where the strapping head is at one extreme of movement along the coil periphery, to enable the strap loop to wrap the coil tight by rotating as a capstan and shrinking in size as the head moves in a wrapping direction along the coil periphery and maintains tension by taking up slack as the wrapping action reduces the outer diameter of the coil, and to enable sealing of the strap loop when the head is at the point where the coil is fully wrapped.

The general path of movement of the strapping head may be traced with reference to FIGS. 8, 9, and 10. The horizontal carriage 26 first moves the head mounting plate 25M directly towards the coil periphery as illustrated in FIG. 8. A novel linkage system then moves the head mounting to the start position which represents one extreme of movement of the head along the coil periphery. At this point, the head plate 25M and hence the head 25 are in tangency to the coil periphery and tension is drawn to bring the loop snug and tend to rigidify the outer wrap of the coil 31. The head 25 is now moved in a wrapping direction (indicated by the arrow W in the drawings) along the coil periphery to move from the FIG. 9 position towards the FIG. 10 position, with the head being maintained tangent to the coil periphery. This wrapping movement is applied to the outer wrap of the coil by the gripping action of the revolving strap loop S, and as the wrapping action tightens the coil and reduces its diameter, the head pulls the strap to maintain a snug grip of the loop on the shrinkage outer wrap. The wrapping movement will stall when the coil is tight, usually before the opposite limit position of movement is reached.

The actual wrapping stroke may be completed in less than 4 or 5 seconds but final sealing of the strap loop is timed to occur only after a certain interval (4 or 5 seconds in this example) which is selected to allow completion of a maximum length wrapping stroke and also to allow for full thermal expansion of the strap loop due to contact with the high temperature coil. When the preselected interval times out, proper tension will already exist on the strap loop and the opposite ends of the loop are sealed and the supply end severed to free the head of the coil.

The head 25 now returns to the FIG. 8 position and the horizontal carriage 26 thereafter retracts. When the carriage 26 is fully retracted, the main carriages 12 and 17 are raised to elevate the entire mechanism to its upper position wherein the guide segments 27, 28, 29 and 30 are in alignment and the head 25 feeds strap to preform a loop for the next coil. The support arms 34 are pivoted to a retracted position and allow the tied coil to advance and a new coil to arrive as soon as the head 25 is retracted and without waiting for full elevation of the carriages 12 and 17.

In one embodiment, such as is illustrated herein, the strapping station equipped with a head movement and positioning system of this invention can handle wrapping and tying of coils of any diameter within a range of 36 inches to 72 inches. In the diagram of FIGS. 8, 9 and 10, an ideal coil size of 60 inch diameter is illustrated

and a maximum wrapping stroke of about 40 inches along the coil periphery is accomplished.

As is described in detail hereafter, the head movement and positioning system is automatically adaptable to the coil periphery to guide the head **25** along the coil periphery, with the head maintained tangent to the periphery. This automatic orientation of the head **25** not only adapts the equipment to coils of various different diameters but it reduces the requirement for exact registry of the center lines of the coil and the strapping station. By way of example, for the arrangement illustrated herein, a 60 inch coil can be accepted with its axis plus or minus 6 inches from the station center line and the head movement can generate a wrapping stroke of at least 24 inches along the coil periphery.

In FIG. 11, the periphery **31P** of a coil **31** is shown exactly on center; the periphery **31P'** is shown for a coil 6 inches off center to the left and the periphery **31P"** is shown for a coil 6 inches off center to the right. The ease with which such variations in center registry are accommodated should be apparent from a comparison of the corresponding head tangency positions **25**, **25'** and **25"**.

The carriage **17** which mounts the horizontal slide carriage has corresponding end plates **17A** and **17B** (see FIGS. 1, 3 and 7) each provided with a plurality of outboard rollers **17C** positioned to roll along the vertical post members **6** and **7** to maintain positional stability of the carriage **17** as it is raised or lowered by the chains **18** and **19**.

The end plates **17A** and **17B** are each provided with inboard rollers **17D** arranged in two horizontal rows which receive and guide the side rails **26R** of the horizontal slide carriage **26** and permit movement of the carriage through a predetermined path in a horizontal plane. As best seen in FIG. 3, the carriage **26** is stabilized by front cross brace structure **35** and rear cross brace structure **36**, each connected rigidly to each of the side rails **26R**. The front cross brace structure **35** has an upstanding web **35W** for strength and is provided with an arcuate ledge **35L** defining a guideway controlling the movement path of a pair of rollers **37**. The rear cross brace structure **36** has an upstanding reinforcement web **36W** equipped with rear bracket structure **36B** that mounts a vertical pivot shaft **38** at the rear of the carriage **26**.

A wrapping arm **39** extends centrally of the carriage **26** and is provided at the front with a blunt wedge shaped web portion **39W** and a circular reinforcement plate portion **39P** and is provided at the rear with a vertical sleeve **39S** journalled on the pivot shaft **38** which defines an axis of swinging movement for the wrapping arm. The ledge **35L** provided on the front cross brace structure has its center of curvature at the axis of the pivot shaft **38**, and rollers **37** are journalled in the web **39W** to roll along the ledge **35L** and support the front of the wrapping arm in wheeled engagement for free swinging movement. The rear of the wrapping arm **39** extends through the vertical web **36W** of the rear cross brace structure **36** with sufficient clearance to accommodate required horizontal swinging movement of the wrapping arm.

A set of parallel positioning links **41** and **42** extend in flanking relation alongside and slightly below the wrapping arm **39**. As best seen in FIGS. 3 and 6, a drive arm assembly **43** consisting of upper and lower coacting drive arms **44** and **45**, respectively, mounted on opposite ends of a vertical pivot shaft **46** journalled in the wrapping arm **39** carries a separate vertical pivot shaft **47** and **48** connected to the rear of the links **41** and **42**, respectively.

A stabilizing cross arm **67** (FIG. 5) underlies the wrapping arm **39** and is rotatable on a vertical pivot shaft **68** carried by the wrapping arm **39**. The stabilizing cross arm **67** is, in turn, equipped with depending pivot shafts **69** and **70** which form pivotal connections to the links **41** and **42**. The drive arms **44** and **45** together with the stabilizing cross arm **67** complete the parallel linkage system.

A tangency position sensing unit T is carried at the front of the links **41** and **42**. As best seen in FIGS. 3 and 4, this sensing unit includes a separate vertical pivot shaft **49** and **50**, respectively, carried at the front of each of the positioning links **41** and **42**. A horizontal top support plate **51** receives the upper ends of the pivot shafts **49** and **50** and a bottom cross plate **52** receives their lower ends. The support plate **51** carries the head mounting plate **25M** (FIG. 2). The movement of the drive arms **44** and **45** acts through the links **41** and **42** to effect swivelling movement of the support plate, mounting plate **25M** and head **25** as is necessary for maintaining tangency to the coil periphery during the wrapping stroke.

To sense tangency of the head **25**, a position sensing element **53** is mounted in rotatable relation between the plates **51** and **52**. The sensing element **53** includes a central vertical hub **53H** that is journalled on a pivot shaft **54** which has its opposite ends carried in the plates **51** and **52**. The sensing element **53** has symmetrically arranged forwardly diverging cam arms **53C** radiating from the hub **53H** and each carrying a cam roller **54** and **55** normally located in partially projecting relation through the open front face of the tangency sensing unit T. Finally, the sensing element **53** has a rearwardly radiating switch actuating arm **53A** centered between a pair of limit switches **LS20** and **LS21**.

The centerline of rotation of the tangency sensing assembly T coincides with the center line of the sealer jaws of the head **25**. When the head **25** is tangent to the coil periphery, the rollers **54** and **55** engage the coil evenly and the actuating arm **53A** remains centered between the limit switches **LS20** and **LS21**. When the head **25** inclines a predetermined extent from tangency in either direction, the rollers sense the change and cause the actuating arm **53A** to operate a corresponding one of the limit switches for adjusting the head position through the action of the drive arms **44** and **45** and the positioning links **41** and **42**.

Reference may now be had to FIGS. 3 and 12 for a disclosure of the hydraulic cylinders that operate to position the horizontal carriage **26**, the wrapping arm **39**, and the links **41** and **42** and plates **51** and **26M**.

As shown in FIG. 12, a cylinder **56** for positioning the horizontal slide carriage **26** is selectively operated by a hydraulic solenoid valve **SH2** under the control of solenoids **SH2A** and **SH2B**. A wrapping cylinder **57** for positioning the wrapping arm **39** is operated by a hydraulic solenoid valve **SH11** under the control of solenoids **SH11A** and **SH11B**. A limit switch assembly **58** including limit switches **LS22**, **23**, **24**, **25**, and **28** is associated with the wrapping cylinder **57**. Limit switch **LS28** is shown in FIG. 13 and is closed when the wrapping arm **39** is ahead of center while limit switch **LS23** is closed when the wrapping arm is beyond the center of its stroke. Finally, a head positioning cylinder **59** is operated by a hydraulic solenoid valve **SH12** under the control of solenoids **SH12A** and **SH12B**. A limit switch assembly **60** including limit switches **LS26** and **LS27** is associated with the head positioning cylinder **59**.

As best shown in FIG. 3, the horizontal carriage cylinder **56** has its cylinder body **56B** rigidly secured to a side plate **61** at its closed front end and rigidly secured to an inboard mounting bracket **62** carried on the side rail **26R** and has its piston rod **56R** anchored at its free rear end to a reaction bracket **63** carried on the end plate **17B**. The wrapping cylinder **57** has its cylinder body **57B** pivotally secured at its closed end to an inboard mounting bracket **64** which is fixed on the other side rail **26R** and equipped with a pivot pin **64P** and has its piston rod **57R** pivotally secured at its free end to an upstanding pivot pin **65** carried on the reinforcement plate portion **39P** of the wrapping arm **39**. Finally,

the head positioning cylinder 59 has its cylinder body 59B pivotally secured at its closed end to an extension 62E of the mounting bracket 62 which is equipped with a pivot pin 62P and has its piston rod 59R pivotally secured at its free end to a pivot pin 63 carried on the upper drive arm 44.

For simplicity in illustrating the action of the linkage structure shown in FIGS. 2 to 7, the elements are represented diagrammatically in a functionally similar parallel linkage system in FIGS. 8 to 11. Thus, the wrapping arm 39, the positioning links 41 and 42, the drive arm 44, the sensing element 53, the head 25, the wrapping cylinder 57 and the head positioning cylinder 59 bear the same reference characters in all of these drawings.

Sequence of operation

In describing the novel wrapping technique of the present invention, it is assumed that the horizontal slide carriage 26 is at the proper desired height with respect to the coil for locating the strap loop. It will also be assumed that the strap loop which encircles the coil has its leading end engaged by the gripping jaws of the head 25 and has its supply end extending through the tensioning wheel in the head.

Under these conditions, certain circuitry, not specifically shown in FIG. 13, receives a signal and energizes the solenoid SH2A to activate the cylinder 56 and advance the horizontal slide carriage 26 towards the coil 31. A bumper switch LS12 (FIGS. 7 and 13) mounted adjacent the head 25 has an activating lever arm 66 projecting forwardly and serving as the initial coil contacting element. When the slide 26 approaches the coil 31, the lever 66 operates the bumper switch LS12 to energize relays CR5 and TR15. Since relay 3TR had previously been energized under the control of a limit switch LS1 (FIGURE 13) which senses the relationship of the strap loop to its guide track structure, a circuit is completed to solenoid SH11B to control hydraulic solenoid valve SH11 and energize the wrapping cylinder 57 for swinging the wrapping arm 39 towards its start position as illustrated in FIG. 9. This is the position for the start of the wrapping action.

It may be noted that as the wrapping arm 39 is swinging towards its start position, the horizontal slide carriage 26 is still advancing towards the coil 31, with these combined effects maintaining the head 25 in contact with the outer wrap of the coil. Under these conditions, there is a concurrent natural motion of the linkage effecting desired head rotation for achieving tangency; however, if exact tangency is not attained, the appropriate sensing roller 54 or 55 predominates to operate either limit switch LS20 or limit switch LS21. Limit switch LS20 is connected to complete a circuit to solenoid SH12B to operate head positioning cylinder 59 in one sense of rotation. Correspondingly, limit switch LS21 is connected to complete a circuit to solenoid SH12A to operate head positioning cylinder 59 in an opposite sense of rotation. Thus, head position is appropriately modified under the control of limit switches LS20 and LS21 to assure essential tangency.

When the wrapping cylinder 57 has swung the wrapping arm 39 until the head actually reaches the start position illustrated in FIG. 9, limit switch LS22 closes and energizes solenoid SH3A. At this time, a circuit is also completed to a time delay relay ITR. The solenoid SH3A controls application of hydraulic power to drive the take up wheels of the strapping head in a strap tensioning direction. When the strap loop is tight to the coil, the head 25 is in effect clamped to the outer wrap of the coil.

As the strap loop is fully tightened onto the coil 31, it is stripped from the strap guide structure associated with the head 25, thus releasing limit switch LS1 and opening the circuit to relay 3TR. When relay 3TR de-energizes, its contacts 3TR4 and 3TR5 flip-flop to de-energize solenoid SH11B and energize solenoid SH11A. This reverses the action of the wrapping cylinder 57 for swinging the wrapping arm 39 in a coil wrapping direction.

Concurrently, contact 3TR3 has opened to de-energize solenoid SH2A and relieve the hydraulic force acting to urge the slide carriage 26 towards the coil. A limit switch LS28, which closed when the wrapping cylinder 57 advanced the head 25 to its start position, establishes a circuit to solenoid SH2B. Control relay CR24 has picked up when contact 3TR1 closed and its contact CR24–1 completes the energizing circuit to solenoid SH2B. Solenoid SH2B controls application of reverse hydraulic power to cylinder 56 gradually to retract the horizontal slide carriage 26.

Thus, the combined actions of the slide cylinder 56 and the wrapping cylinder 57 move the head 25 along a path on the coil periphery extending from the FIG. 9 position to the FIG. 8 position. Head tangency is maintained during such movement by the action of the sensing rollers 54 and 55 and limit switches LS20 and LS21.

The resultant force developed by the combined actions of the cylinders 56 and 57 is directed tangential to the coil. The clamped relationship of the head 25 and the strap loop against the outer wrap of the coil provides a capstan effect in the presence of this tangential force so that the wrapping motion of the head acts to tighten the loose outer wraps of the coil.

As the coil is tightened, its circumference shrinks continually presenting an incipient slack condition tending to reduce the clamping action of the strap loop against the outer wrap of the coil. It is important in the preferred practice of the invention that the type of strapping head continuously exert a constant tensioning action to take up slack promptly as the coil size shrinks. The clamping action of the strap loop is thus maintained and the capstan action is therefore effective throughout the wrapping stroke.

As the head 25 moves from the start position of FIG. 9 and approaches the FIG. 8 position, limit switch LS28 opens to de-energize solenoid SH2B to deactivate slide cylinder 56. At this approximately normal position, the wrapping cylinder 57 can apply the wrapping force in approximately the proper direction.

If the head 25 moves beyond the FIG. 8 position, towards the FIG. 10 position, the required wrapping action has an inward component. For this purpose limit switch LS23 closes when the wrapping arm 39 moves overcenter. Limit switch LS23 closes to complete a circuit to solenoid SH2A for again moving the slide carriage 26 towards the coil 31.

Now the combined actions of the slide cylinder 56 and the wrapping cylinder 57 move the head 25 along a path on the coil periphery extending from the FIG. 8 position to the FIG. 10 position. Head tangency is again maintained by the action of the sensing rollers 54 and 55 and limit switches LS20 and LS21.

The maximum possible duration of the wrapping stroke is determined by the time delay relay 1TR which typically allows approximately 4 to 5 seconds from start to stop of wrap. In many instances, however, the coil is fully tightened at an intermediate stage of the wrapping cycle. In these situations, the wrapping action will stall when the coil becomes tight.

The time delay function of the relay serves two purposes. It allows the necessary length wrapping stroke and it allows the strap to come up to temperature with the hot coil before permitting sealing of the joint. When the relay ITR times out, its contacts 1TR–1 and 1TR–4, respectively, open to de-energize the tensioning solenoid SH3A and the wrapping solenoid SH11A, and its contact ITR–3 energizes the sealing solenoid SH4, permitting the head to complete the seal joint and shear the strap. The sealer jaws of the head then open and free the head of the coil. The limit switch LS3A then opens to de-ener-

gize relay CR–5 and its contact CR5–1 opens to de-energize relay TR15.

The normally closed contact TR15–2 returns to closed position to establish circuits to solenoids SH11A and SH11B; these circuits will be selectively completed through limit switches LS25 and LS24, depending on the position of the wrapping arm 39 at the end of the wrapping stroke. If the head 25 and wrapping arm 39 have passed through the FIG. 8 position during the wrapping stroke, LS24 will be closed and LS25 will be open; but if the head 25 has stalled before reaching the FIG. 8 position, LS25 will be closed and LS24 will be open. In either event, the wrapping arm 39 is powered in the appropriate direction to return it to the FIG. 8 position. During this return travel, the contact TR15–5 establishes circuits to solenoids SH12A and SH12B to be completed selectively through limit switches LS20 and 21. This permits the head 25 to maintain tangency during its return to neutral position. When TR15–4 and TR15–5 time out, LS26 and LS27 assume control of SH12A and SH12B to bring the head to neutral position. When the head reaches neutral position and is in a tangent relationship, both limit switches LS26 and LS27 are open.

When the wrapping cylinder 57 is at its midpoint, the series connected contacts of limit switches LS24 and 25 are closed to complete a circuit to solenoid SH2B for retracting the slide 26 from the coil. After complete retraction of the slide, the entire carriage 17 is elevated until the strap guide segments 27, 28, 29 and 30 are in alignment. It is for purposes of alignment of these strap guide segments that the wrapping arm 39 and the head 25 must be centered after completion of the strap joint.

Thus, while the preferred constructional features of the invention are embodied in the structure illustrated herein, it is to be understood that changes and variations may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

What is claimed is:

1. The method of wrapping a spiral coil comprising, providing a strap loop in encircling relation to the coil, shrinking the strap loop into contact with the outer wrap of the coil, maintaining such contact of the strap loop while rotating the entire loop in a direction to wrap the coil tight.

2. The method of wrapping a spiral coil comprising, providing a strap loop in encircling relation to the coil, shrinking the strap loop into contact with the outer wrap of the coil, maintaining such contact of the strap loop while rotating the entire loop in a direction to wrap the coil tight, and thereafter sealing the strap loop to hold the coil tight.

3. The method of wrapping a spiral coil comprising, providing a strap loop in encircling relation to the coil, shrinking the strap loop into contact with the outer wrap of the coil, rotating the entire strap loop in a direction to wrap the coil tight while concurrently taking up incipient slack in the strap loop due to such rotation to maintain contact with the outer wrap.

4. The method of wrapping a spiral coil comprising, supporting the coil at one axial end thereof, providing a strap loop axially spaced beyond the other end thereof, producing relative axial movement therebetween to bring the strap loop in encircling relation to the coil, shrinking the strap loop into gripping contact with the outer wrap of the coil, and maintaining such gripping contact of the strap loop while rotating the entire strap loop in its own plane in a direction to wrap the coil tight.

5. The method of wrapping a spiral coil comprising, supporting the coil at one axial end thereof, providing a strap loop axially spaced beyond the other end thereof, producing relative axial movement therebetween to bring the strap loop in encircling relation to the coil, shrinking the strap loop into gripping contact with the outer wrap of the coil, and maintaining such gripping contact of the strap loop while rotating the entire strap loop in its own plane in a direction to wrap the coil tight, and thereafter sealing the strap loop to hold the coil tight.

6. The method of wrapping and tying a spiral coil comprising, supporting the coil at one axial end thereof, providing a strap loop axially spaced beyond the other end thereof, producing relative axial movement therebetween to bring the strap loop in encircling relation to the coil, shrinking the strap loop into gripping contact with the outer wrap of the coil, rotating the entire strap loop in its own plane in a direction to wrap the coil tight while concurrently taking up incipient slack due to such rotation to maintain gripping contact with the outer wrap, and therafter sealing the strap loop to hold the coil tight.

7. The method of wrapping and tying a spiral coil to tighten any of its loose wraps comprising, supporting the coil at its bottom end with its axis vertical, providing a strap loop axially spaced above the other end thereof, producing relative vertical movement therebetween to bring the strap loop in encircling relation to the coil, shrinking the strap loop into gripping contact with the outer wrap of the coil, producing relative rotary movement in a horizontal plane between the coil and strap loop in a direction to wrap the coil tight while concurrently taking up incipient slack due to such rotation to maintain gripping contact with the outer wrap, and thereafter sealing the strap loop to hold the coil tight.

8. The method of wrapping and tying a hot spiral coil to tighten any looseness in the coil wraps comprising, supporting the coil with its axis vertical, providing a strap loop axially spaced from the coil, producing relative axial movement therebetween to bring the strap loop in encircling relation to the coil, shrinking the strap loop into gripping contact with the outer wrap of the coil, producing relative rotary movement between the coil and strap loop in a direction to wrap the coil tight while concurrently taking up incipient slack due to such rotation to maintain gripping contact with the outer wrap, allowing sufficient time for thermal expansion of the strap loop occasioned by its contact with the coil, and sealing the strap loop to hold the coil tight.

9. Apparatus for wrapping a spiral coil, said apparatus comprising, a strapping head having feed means for feeding strap to form a strap loop having the opposite ends of the strap loop overlapped, tension means to take up slack to tighten the strap loop, and sealing means for sealing the opposite ends of the strap loop, means for moving the head to a start position adjacent to the coil periphery in a coil wrapping direction while the tension means maintains the strap loop tight upon the coil, and means for returning the head to a strap loop forming position after the sealing means seals the strap loop tight upon the coil.

10. Apparatus for wrapping a hot spiral coil, said apparatus comprising, a strapping head having feed means for feeding strap to form a strap loop having opposite ends of the strap loop overlapped, tension means to take up slack to tighten the strap loop, and sealing means for sealing the opposite ends of the strap loop, means for moving the head to a start position adjacent to the coil periphery where the tension means tightens the strap loop about the coil, means for moving the head along the coil periphery in a coil wrapping direction while the tension means maintains the loop tight upon the coil, means for delaying operation of said sealing means until thermal expansion of the loop occasioned by contact with the coil is substantially complete, and means for returning the head to a strap loop forming position after the sealing means seals the strap loop tight upon the coil.

11. In a system for wrapping a spiral coil by means of a strapping head that feeds strap to form a strap loop having opposite ends of the strap loop overlapped, takes up slack to shrink the loop and tension the strap of the strap loop and maintains strap loop tension, head positioning apparatus including a carriage movable general-

ly toward and away from the coil, a parallel arm linkage pivotally mounted on the carriage and supporting the head forwardly of the carriage, and drive means for the carriage and the linkage for moving the head adjacent to the coil periphery and along the coil periphery in a coil wrapping direction.

12. In a system for wrapping a spiral coil by means of a strapping head that feeds strap to form a strap loop having opposite ends of the strap loop overlapped, takes up slack to tighten the strap loop and tensions the strap of the strap loop and maintains strap loop tension, head positioning apparatus including a carriage movable generally toward and away from the coil, a parallel arm linkage pivotally mounted on the carriage and having a forward mount supporting the head, tangency sensing means on the mount engageable with the coil to respond selectively when the head is out of proper tangency with the coil, drive means for the carriage and the linkage, and control means connected between the tangency sensing means and the drive means for controlling the drive means to reestablish proper tangency of the head relative to the coil while moving the head along the coil periphery in a coil wrapping direction after the strap loop is tightened.

13. In a system for wrapping a spiral coil by means of a strapping head that feeds strap to form a strap loop having opposite ends of the strap loop overlapped, takes up slack to tighten the strap loop and tensions the strap of the strap loop and maintains strap loop tension, comprising, head positioning apparatus including a carriage movable generally toward and away from the coil, a parallel arm linkage pivotally mounted on the carriage and having a forward mount supporting the head, tangency sensing means on the mount engageable with the coil to provide a signal when the head is out of proper tangency with the coil.

14. In a system for wrapping a spiral coil by means of a strapping head that feeds strap to form a strap loop having opposite ends of the strap loop overlapped, takes up slack to shrink the loop and tensions the strap of the strap loop and maintains strap loop tension, comprising, head positioning apparatus for supporting the head including a carriage movable toward and away from the coil, a head mount on the carriage, a wrapping arm aligned with said mount and supported on said carriage to rotate about an axis parallel to the axis of the coil, a positioning arm flanking said wrapping arm and having a forward end pivotally connected to the mount and having another pivotally connected to a drive link that is pivoted on the wrapping arm, and separate drive means for the carriage, the wrapping arm and the drive link cooperable for moving the head adjacent to the coil periphery and along the coil periphery in a coil wrapping direction.

15. In a system for wrapping a spiral coil by means of a strapping head that feeds strap to form a strap loop having opposite ends of the strap loop overlapped, takes up slack to shrink the strap loop and tensions the strap of the strap loop and maintains strap loop tension until finally sealing the opposite ends of the strap loop, head positioning apparatus for supporting the head including a carriage movable toward and away from the coil, a head mount, a wrapping arm aligned with said mount and supported on said carriage to rotate about an axis parallel to the axis of the coil, a pair of parallel positioning arms flanking said wrapping arms and having corresponding forward ends pivotally connected to spaced regions of the mount, and having corresponding rear ends pivotally connected to spaced regions of a drive link that is pivoted on the wrapping arm, a cross link pivotally carried on the wrapping arm forwardly of the drive link and having spaced regions pivoted to the positioning arms, drive means for the carriage, the wrapping arm and the drive link for moving the mount and the head along the coil periphery in a coil wrapping direction, control means connected to the drive means, and tangency sensing means on the mount engageable with the coil to actuate the control means when the head is out of proper tangency with the coil, said control means causing the drive means to urge the head into proper tangency with the coil.

16. Apparatus for wrapping a spiral coil comprising, a strap feed device for feeding a length of strap into a strap loop and positioning the strap loop circumferentially around the coil, said strap feed device being part of a head swingably secured on a frame mounted for movement toward and away from the location of the coil to be wrapped, said frame also being swingably mounted to direct the head in an arc along the periphery of the coil, and drive means for causing said swingably movement of the frame, tangency sensing means associated with the head, and control means connected between the tangency sensing means and said drive means for maintaining the head in approximate proper tangency with the coil during the swingable movement of the frame.

17. Apparatus for strapping a cylindrical object comprising, a strapping head of a type having means for securing together the overlapping ends of a strap loop circumferentially encircled about the object, the strapping head being mounted on a frame for angular movement, reversible drive means on the frame connected to selectively rotate the strapping head in either a clockwise or counterclockwise direction, a sensing means associated with said strapping head for contacting the peripheral surface of the object to be strapped, said sensing means being deflected one way by the surface of the object when the strapping head is at a clockwise angle with respect to the strapping location of the surface of the object and deflected in the opposite way by the surface of the object when the strapping head is at a counterclockwise angle with respect to the strapping location of the surface of the object, said sensing means being nondeflected when the strapping head is properly tangent to the strapping location of the surface of the object, said sensing means being connected to cause said reversible drive means to rotate the strapping head counterclockwise when the sensing means is deflected said one way and to cause said reversible drive means to rotate the strapping head clockwise when the sensing means is deflected said opposite way.

18. The apparatus defined by claim 17 characterized by, the connection between said sensing means and said reversible drive means being electrical switch means.

19. Apparatus for wrapping a spiral coil comprising, a coil support, strapping means adjacent to the coil support for providing a strap loop in encircling relation to the coil, tightening means on said strapping means for shrinking the strap loop and tightening the strap loop into contact with the outer wrap of the coil, and means attached to the strapping means for rotating the strapping means through an arc concentric with the axis of the coil to rotate the entire strap loop while it is in contact with the outer wrap of the coil in a direction to wrap the coil tight.

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