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(54) STRAPPING MACHINES

(71) We, SIGNODE CORPORATION, a Corporation organised under the laws of the State of Delaware, United States of America, of 3600 West Lake Avenue, Glenview, Illinois 60025, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to strapping machines. Such machines encircle a package with strapping and establish a loop having overlapping ends, unite such ends to provide a joint, and then sever the banded package from the excess strapping.

In the commercial banding of packages, three basic methods of strap application are presently used. In one method the strapping is forced endwise through a chute which at least partially encircles the package so that after a loop having overlapping ends is established it may be tensioned to withdraw it from the chute and firmly wrap the package, after which the overlapping ends are sealed together and the severing operation performed. With this method careful measuring of the feed strapping must be made to avoid overfeeding or underfeeding and also frictional problems arise as the strap slides through the chute. In another method, the free end of the strapping is drawn around the package by a carrier which orbits the package and brings such free end back to its starting point so that the necessary overlap may be established, sealed and severed. With this method only the wrapping operation is automatic and manual sealing and cut-off operations must be resorted to. In a third method which largely eliminates the problems of the first two methods, the free end of the strapping is clamped near the package and a slip-feed carrier through which the strapping slides orbits the package and draws a reentrant bend of strapping around the package in one direction until a closed loop encircles the package and its overlapping ends are then sealed and severed. The severed end is again clamped and the carrier orbits the package in the opposite direction to draw a second reentrant bend around the package and perform a similar banding, sealing and severing operation. It is to

this third mention of package bending that the present strapping apparatus specifically relates.

According to one aspect of the present invention, there is provided a strapping machine operative upon a length of flexible strapping from a strapping source for forming a closed loop about an object at a strapping area and comprising means for clamping the free end of the strapping in close proximity to the object, a hoop encircling the strapping area, a carrier on the hoop for slip-feed engagement with the strapping between its free end and the strapping source, means for rotating the hoop to orbit the carrier about the strapping area and transport the strapping about the object to form a loop having overlapping end portions, a fixed strap guide adjacent a region of the hoop circumference and located at a point along the path followed by the strapping between the carrier and the strapping source for guiding strapping to the carrier, a strap dispensing and storing mechanism interposed between the fixed strap guide and the strapping source for taking up slack in the strapping as the carrier approaches the fixed strap guide and for paying out strapping as the carrier recedes from the fixed strap guide, said mechanism embodying a secondary strap storage region for receiving strapping from the strapping source and a primary strap storage region for receiving strapping from the secondary region, a releasable strap clamping device normally effective upon the strapping between the primary and secondary strap storage regions for preventing strapping from entering the primary strap storage region from the secondary strap storage region, means for releasing the strap clamping device when a major portion of the strapping in the primary strap storage region has been paid out to permit strapping to be drawn from the secondary strap storage region to the primary strap storage region, means for sealing the overlapping end portions to each other after terminal rotation of the hoop, and means for severing the thus sealed loop from strapping coming from the fixed strap guide.

According to a second aspect of the present invention, there is provided a strapping machine for wrapping flexible strapping from a strapping source about an object at a strapping area to

provide a tensioned strap loop having overlapping end portions and comprising a strap dispensing and storing mechanism, means for clamping the free end of the strapping, a circular hoop encompassing the strapping area, means for rotating the hoop, a carrier on the hoop for slip-feed engagement with the strapping between its free end and the strap dispensing and storing mechanism and effective upon rotation of the hoop to orbit the strapping area and conduct strapping around the object to produce a loop, having overlapping end portions, a fixed strap guide adjacent the hoop circumference and located at a point along the path followed by the strapping between the carrier and the strap dispensing and storing mechanism for guiding strapping to the carrier, means for sealing the said overlapping end portions to each other after terminal rotation of the hoop, and means for severing the thus sealed loop from the strapping source, the strap dispensing and storing mechanism including a secondary strap storage region for receiving strapping from the strapping source and a primary strap storage region for receiving strapping from the secondary strap storage region, the primary region serving to draw strapping from the hoop back through the fixed strap guide during initial rotation of the hoop and thereafter to supply the stored strapping to the hoop through the fixed strap guide during continued rotation of the hoop, the secondary strap storage region serving to draw strapping from the source during further rotation to provide reserve strapping for subsequent transfer to the primary strap storage region after a major portion of the strapping in the primary region has been exhausted, a releasable strap clamping device normally effective upon the strapping between the primary and secondary strap storage region for preventing strapping from entering the primary strap storage region from the secondary strap storage region, and means for releasing the said strap clamping device when the said major portion of the strapping in the primary region has been paid out to permit strapping to be drawn from the secondary strap storage region to the primary strap storage region.

With slip-feed strapping systems difficulties arise in pulling strapping directly from a source of strapping such as a reel since inertia places a heavy tension in the strapping tending to dislodge the package from its support. With apparatus constructed in accordance with the present invention, there is created a length of excess strapping which is not immediately applied to the package and is therefore returned to the dispensing system and stored until it is needed for wrapping purposes. At this time it is again withdrawn.

Another limitation associated with slip-feed wrapping apparatus resides in the complexity of the slip-feed carrier which heretofore has been carried by an endless chain which encompasses the strapping area and is reversible in opposite

directions for carrier orbiting purposes. The driving mechanism for such chain involves drive and idler sprockets and involves a complicated system which is noisy in its operation and requires a large number of movable parts. The carrier supporting chain has associated therewith a power driven slack take-up chain and all of these devices increase maintenance costs.

In a machine constructed according to the present invention, in place of a chain supported slip-feed carrier, the carrier is mounted on a hoop which encompasses the strapping area and is conveniently mounted on pinch rollers, with the entire arrangement being conducive towards extreme simplicity and quietness as well as cost reduction.

The invention may be carried into practice in various ways but one strapping machine embodying the invention and a modification of the machine will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a front view of the strapping machine;

Figure 2 is an enlarged front perspective view of a portion of the dispenser section of Figure 1;

Figure 3 is an enlarged rear view of another portion of the dispenser section shown in Figure 1;

Figure 4 is a schematic fragmentary front view, showing the carrier shortly after one face of a rectangular package has been wrapped in a clockwise direction;

Figure 5 is a front view showing the position of the carrier after the strap has been almost completely wrapped about the package;

Figure 6 is a front view showing the carrier in position after the strap has been wrapped about the package;

Figure 7 is a schematic view showing the carrier in a position of rest at a point near the end of its clockwise motion;

Figure 8 is a schematic view showing the carrier at the end of its clockwise motion;

Figure 9 is a schematic view showing the carrier at the commencement of its counter-clockwise motion with the sealing operation in progress;

Figure 10 is a schematic view showing the termination of the sealing operation;

Figure 11 is a schematic view showing the carrier in a position of rest preparatory to complete withdrawal of the sealing instrumentalities from the strap loop;

Figure 12 is a schematic view, similar to Figure 11, showing the sealing and gripping instrumentalities withdrawn;

Figure 13 is a schematic view showing the strap loop severed from the source of strapping and the free end of the strap gripped preparatory to banding of the package in a counter-clockwise direction;

Figure 14 is a fragmentary front view of a modified form of dispenser section;

Figure 15 is a fragmentary front perspective view, similar to Figure 2, showing a portion of the modified dispenser section of Figure 14;

Figure 16 is an enlarged section on line 16-16 of Figure 1;

Figure 16a is a section on line 16a-16a of Figure 16;

Figure 17 is a section on line 17-17 of Figure 16;

Figure 18 is a section on line 18-18 of Figure 16;

Figure 19 is a section on line 19-19 of Figure 16;

Figure 20 is a section on line 20-20 of Figure 19;

Figure 21 is a section on line 21-21 of Figure 16;

Figure 22 is a section on line 22-22 of Figure 21;

Figure 23 is a section, similar to Figure 22, showing the parts in a different position;

Figure 24 is a section on line 24-24 of Figure 20;

Figure 25 is a section, similar to Figure 24, showing the parts in a different position;

Figure 26 is a section on line 26-26 of Figure 17; and

Figure 27 is a section, similar to Figure 26, showing the parts in a different position.

Referring particularly to Figure 1, the strapping machine 10 includes a framework 12 which defines a strapping area SA for reception of a box-like package P shown in Figures 4 to 13, inclusive. The package P is not necessarily rectangular and it may be brought into and removed from the strapping area SA either manually or by a suitable conveyor.

At the left side of the framework 12, a strap dispensing and storing section DS includes a strap reel 14 from which strapping S is fed to a slip-feed carrier 16 which orbits the strapping area SA by means of a reversible rotatable hoop 18 on which the carrier is mounted. The strap S issuing from the reel 14 passes through a strap storing and tensioning mechanism which is embodied in the dispenser section DS and is conducted to the strapping area SA where it is acted upon by the orbiting slip-feed carrier 16 and is caused to encircle the package P in a progressive manner and in a clockwise direction until the package is completely surrounded by a closed loop of the strapping having a slight overlap at the bottom of the hoop 18 at a sealing station SS.

Sealing instrumentalities, at the station SS include a horizontally slidable anvil 20 and a cooperating oscillatable vibrator 22 (Figures 4 through 13) which operate upon the strap overlap in a wellknown manner and as exemplified by United States Patent No. 3 548 740, granted December 22, 1970, to melt the overlapping layers of the strap loop overlap and create a seal, after which a cutter knife 24 (Figures 16, 20, 26, and 27) severs the loop from the source of strapping.

After the strap loop has been severed, a counterclockwise motion of the hoop takes place and the slip-feed carrier orbits the strapping area SA and returns to its original position. During such counterclockwise motion, the strap is again wrapped about the package but in the opposite direction with substantially the same machine functions taking place.

Still referring to Figure 1, the framework 12 includes a base 26 embodying corner posts 30 and 32 which support an upper table 34. Lower anglepieces 36 and intermediate frame bars 38 (see also Figure 16) extend across the base 36. Projecting above the table 34 is an inverted U-shaped frame 39 including side members 40 and 42 and a top member 44, such frame and table 34 surrounding the strapping area SA, where a package such as the package P shown in Figures 4 to 13 inclusive may rest upon the table 34.

The hoop 18 is mounted for alternate rotation in opposite directions by means of a reversible electric hoop motor M1 which is connected to a friction drive roller 46 by a belt and pulley 48. The drive roller 46 functions as one of four outside centering rollers including rollers 50, 52 and 54, these rollers being equally spaced around the hoop 18. The rollers 46 and 54 cooperate with inside backing rollers 56 and 58. The drive roller 46 embodies a braking mechanism 59.

A sealing mechanism 60 at the strapping station SS embodies the aforementioned anvil 20 (see Figures 4 to 13 inclusive) and a pair of cooperating grippers 64 and 66 on opposite sides thereof. The gripper 64 cooperates with the right side of the anvil 20 to clamp the free end of the strap S during clockwise wrapping, while the gripper 66 cooperates with the left hand side of the anvil 20 during counterclockwise wrapping.

Figures 1 and 4 to 7 are sequence views showing the motion of the hoop 18 and carrier 16 during clockwise wrapping. Figure 1 represents the starting position wherein the gripper 64 clamps the strap S against the anvil 20 and the strap passes between a pair of slip rollers 70 on the carrier. The carrier assumes a seven o'clock position. From the rollers 70, the strap passes around three of a series of eight circumferentially spaced grooved spreader rollers 72 and from the last of these three rollers 72, the strap passes between a pair of slightly spaced apart centering rollers 74 on a bracket 76, constituting a fixed strap guide. The strap S then passes into a strap storing and tensioning section of the dispensing section DS and is operated upon variously as the hoop 18 continues its rotation, in a manner that will be made clear subsequently.

Referring now to Figure 4 wherein the hoop 18 has been rotated clockwise to a position where the carrier 16 assumes a twelve o'clock position, the spreader rollers 72a, 72b and 72c have released the strap to allow a limited portion thereof to be fed through the centering rollers 74 back into the dispensing section DS.

At the same time, the draping rollers 70 pull the strap inwardly toward the package. The strap is thus wrapped upon the left side of the package P and the tension maintained by the storing mechanism is sufficiently low that it will not displace the package from the table 34.

As shown in Figure 5, wherein the carrier has shifted clockwise to a four o'clock position, the initial motion of the carrier from its twelve o'clock position causes the rollers 70 to pull the strap material out of the dispensing section while the latter still holds the tension so as not to displace the package. As the carrier 16 arrives at the four o'clock position an appreciable quantity of strap has been withdrawn from the dispensing section and applied to the package P so that two faces have been wrapped. While the rollers 70 continue to wrap the strap about the package P, the spreader rollers 72h, 72g and 72f pick up the strap issuing from the centering rollers 74 so that an outside length of strapping material is brought around the partially banded package preparatory to a subsequent cycle of counterclockwise wrapping.

In Figure 6 continued clockwise motion of the hoop 18 shifts the carrier 16 to a seven o'clock position where the draping rollers 70 have pulled the strap against the right side of the package and also have brought the strap beneath the anvil 20 and grippers 64 and 66 so that the package is now completely encompassed. As the strap passes beneath the anvil 20 it establishes a loop overlap which subsequently becomes friction-fused at the strapping station SS under the influence of the sealing member or vibrator 22. At the same time, the spreader rollers 72d, 72e, 72f, 72g, and 72h have increased the extent of the outside length of strapping which has partly encompassed the strapping area SA.

A slight amount of further clockwise rotation brings the carrier 16 to the seven-thirty o'clock position of Figure 7 where the draping rollers 70 are above the level of the table 34 so that the two layers of the strap overlap are firmly pressed against the anvil 20.

In Figure 8, a further small clockwise motion brings the carrier 16 to a terminal eight-thirty o'clock position and, in thus moving, the pull on the strap S represents a final and stronger tensional pull which exceeds the earlier light wrapping tension.

As will be described subsequently with reference to Figures 16 to 27, the anvil 20 and grippers 64 and 66 are horizontally slidable between retracted positions behind the strap loop and projected positions where they extend between the strap overlap and the underneath side of the package P. In Figures 1 and 4 to 8, both the anvil 20 and the grippers 64 and 66 remain in their projected positions. The sealing vibrator 22 is shiftable vertically from the lowered inoperative position of Figures 1 and 4 to 8, and the raised operative position of Figure 9, this latter view representing the sealing operation.

Also horizontally shiftable at the sealing station are a pair of spring-biased direction-reversing lift fingers 80 and 82 which, during the portion of the wrapping cycle illustrated in Figures 1 and 4 to 8, assume positions out of the path of the strap S. However, immediately after the carrier 16 reached the position of Figure 8, reversal of the hoop 18 takes place and the lift fingers become projected into the path of the strap so that as the carrier passes downwardly toward the six o'clock position the strap is brought into contact with the finger 80 as shown in Figure 9.

During this reverse downward movement of the carrier 16, the vibrator 22 commences to vibrate and rise toward the anvil 20. In its uppermost position, the serrated upper edge (see also Figure 21) of the vibrator 20 engages the outer layer of the overlap and presses it against the inner layer which is held motionless by the serrated underneath side of the anvil 20 and slides such outer layer back and forth with a high degree of pressure so as to make a seal by the friction-fusion technique which is described in United States Patent No. 3 442 735, granted 6 May, 1965.

The vibrator 22 is in the form of an oscillatable arm, the lower end of which is secured to the rear end of a rapidly oscillating horizontal rock shaft 84 (Figures 16 and 21) so that the vibrator oscillates in unison with the rock shaft through a small arc. The front end of the rock shaft 84 has fixed thereto the upper end of a slotted crank arm 85 having an axial slot 86. The rock shaft 84 is mounted in bearings 87. A horizontal eccentric shaft 90 carries an offset eccentric 91 which is encompassed by a bearing 93 that rides in the slot 86. The eccentric shaft 90 is supported in bearings 96. Upon rotation of the eccentric shaft 90 oscillation is applied to the crank arm 85 and also to the rock shaft 84, thereby oscillating the vibrator 22. The vibrator 22 normally remains in its lowered position shown in full lines in Figures 16 and 21 and, at this time, it does not vibrate. Only when the vibrator is in its upper position as shown in dotted lines does vibration occur. The vibrator 22, rock shaft 84 and slotted crank arm 85 are shiftable in unison vertically to bring the vibrator 22 into and out of cooperation with the anvil 20, thereby shifting the relationship between the slot 86 and the eccentric 91.

In Figure 10, the carrier 16 is shown as having moved further in its counterclockwise direction with the anvil 20 and grippers 64 and 66 still extending between the strap seal and the package P, the carrier assuming a five o'clock position. During this carrier movement the vibrator 22 returns to its lowered inoperative position while the strap S is pulled around a roller 92 (see also Figures 17 and 19) on the end of the lift finger 80, thus reversing the strap S and commencing the counterclockwise wrapping operation, while at the same time raising the finger to the position of Figure 10.

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In Figure 11, the carrier 16 has shifted counterclockwise and assumes a four-thirty o'clock position and the grippers 64 and 66 are retracted, leaving the anvil interposed between the overlap joint and the package and bringing the strap S into contact with a roller 94 on the lift finger 82.

In Figure 12, the carrier 16 has progressed counterclockwise just past the four-thirty o'clock position where it remains momentarily stationary due to a short dwell on the hoop 18 by means of a timer (not shown). At this time the anvil 20 is withdrawn and the tensioned strap loop snaps upwardly into contact with the package P.

In Figure 13, continued counterclockwise motion of the carrier 16 to its four o'clock position, accompanied by retraction of the lift fingers 80 and 82, releases the rollers 92 and 94 from the strap S so that the lift finger 80 returns to its lowered position. Additionally, the anvil 20 and grippers 64 and 66 again become projected and underlie the wrapped package P. At this time, the left hand gripper is moved to its strap-clamping position and immediately thereafter the cut-off knife 24 (Figure 16) passes beneath the package P and severs the excess strapping to free the strapped package from the source so that it may be removed or shifted to a new position preparatory to counterclockwise banding.

Immediately after the strap cut-off, the hoop 18 and carrier 16 resume their counterclockwise motion and the carrier returns to the initial starting position of Figure 1. During such counterclockwise rotation, a sequence of package banding or wrapping functions similar to those heretofore described in connection with the clockwise banding of the package and sequentially portrayed in Figures 1 and 4 to 13 takes place.

Referring again to Figures 1, 2 and 3, wherein the nature of the strap dispensing and storing section DS is best illustrated, this section includes the aforementioned strap reel 14 which is carried on a bracket 100 and the aforementioned strap storage mechanism which is supported upon a backing plate 102 which, in turn, is supported by upper and lower anglepieces 104 and 105. The backing plate 102 is vertically elongated and the left hand side region of such plate, which is designated by the bracket 106, defines a secondary strap storage region, while the right hand side of the plate which is designated by the bracket 108 defines a primary strap storage region. Supported on an anglepiece 110 is a strap snubbing mechanism 112 which prevents rapid pulling of the strap from the reel 14.

The strap reel 14 is freely rotatable on a shaft 114 and it consists of a central winding hub 116. From the reel, the strap passes through the snubbing mechanism 112 and upwardly where it enters a first pulley system associated with the secondary strap storage region 106 and passes around a pulley 118 and from thence

downwardly and around a pulley 120 on a shiftable yoke 122. The strap then passes upwardly around a pulley 124 and then downwardly around a second pulley 126 associated with the yoke 122, after which it extends upwardly and past a pinch roller 128 on a spring biased arm 129 which cooperates with a fixed snubbing bar 137. From the roller 128 the strap passes into the primary strap storage region 108.

The aforementioned yoke 122 with its two rollers 120 and 126 are thus suspended from two loops of strapping and the base of the yoke is connected to a cable 130 which extends through an abutment 131 and is fixed to a spring-biased drum 132 (see also Figure 2) carried in a cradle 133 suspended by brackets 134 from the plate 102. A spring-biased locking lever 136 normally cooperates with the fixed snubbing bar 137 to prevent pulling of the strapping from the secondary storage region 106.

The snubber mechanism 112 includes a spring-biased arm 140 pivoted at 142 to the anglepiece 110 for limited rocking movement. The arm 140 carries strap guiding rollers 144 and 146 at its ends, and a central compound roller 148. The strap reel 14 embodies a drum upon which the strapping is wound and side flanges 150. The roller 148 includes a pair of outside friction rollers 152 which ride on the rims of the side flanges 150, and a central larger diameter grooved pinch roller 153 which cooperates with a spring-biased pinch roller 154 for strap snubbing purposes. Strapping which is pulled from the dispenser reel 14 passes around the roller 144, between the pinch rollers 153 and 154 and then beneath the roller 146 and upwardly to the pulley 118. Since the rollers 152 ride on the flanges 150 of the strap reel 14, the larger grooved strap roller 153 assimilates any looseness in the strap in the event that the reel tends to overrun the strap feed-out operation. When tension is applied to the strap S an upward force is applied to the roller 146 which tends to raise the compound roller 148 away from the strap reel 14 and thus reduce the effort required to move the latter.

Still referring to Figure 1, strap S passes from the roller 126 to a fixed roller 160 and then enters the primary storage region, passing downwardly around a roller 162 on a second yoke 164. The strap then passes upwardly and around another fixed roller 166 and downwardly around a roller 168 on the yoke 164 from whence it passes upwardly and around a third fixed roller 170. From the roller 170, the strap passes downwardly around a roller 172 on the final tensioning arm 174 (see also Figure 3) and upwardly around a fourth fixed roller 176. The strap then passes to the centering roller 74 of the hoop wrapping system.

Referring again to Figure 2, the drum 132 for the cable 130 is spring-biased by a spring 180 so that a downward pull is applied to the yoke 122 (Figure 1). Similarly, the yoke 164 is

attached to a cable 182 which passes through an abutment 184 and is secured to a drum 186 which is spring-biased by a spring 188.

As shown in Figure 3, the final tensioning arm 174 of the primary storage region is pivoted as at 189 and is biased counterclockwise by a relatively strong spring 190, which exerts a downward force on the arm by means of a pull cable 192 and pulley 194, thus forcing the pulley 172 (Figure 1) against the strap S with appreciable pressure. A stop 196 limits the movement of the tensioning arm 174.

The dispenser section DS is coordinated with the hoop wrapping system by the demand for strapping as it is wrapped around the package P, except for certain timing mechanism which has not been fully illustrated or described herein since such timing mechanism forms no part of the invention. When there is no strap in the machine, both yokes 122 and 164 seat upon the abutments 131 and 184. However, when the strap S is initially applied to the machine as shown in Figure 1, the yoke 122 rests upon its abutment 131 while yoke 164 is raised above the abutment 184.

When the carrier 16 moves to its eleven o'clock position near the centering rollers 74, a certain amount of strap is fed back into the primary storage system 108 but then, as the carrier advances to its twelve o'clock position as shown in Figure 4, a small amount of this strap is again withdrawn.

Movement of the carrier to the four o'clock position of Figure 5 pulls additional strap from the dispenser section as the carrier 16 recedes from the centering rollers 74 and the yoke 164 moves to its uppermost position thus using up the major portion of the strap stored in the primary storage region 108 but not yet withdrawing any strap from that loop in the primary storage region passing over the roller 172, nor any strap from the secondary storage region 106. The spring-biased locking lever 136 ensures exhaustion of the major portion of the strap from the primary storage system 108 before any strap may be withdrawn from the secondary system 106.

When the carrier 16 leaves the position of Figure 5, the solenoid 138 is energized and moves the locking lever 136 from the fixed bar 137 as shown in Figure 6, thereby releasing the strapping so that further demand for strapping by the carrier 16 will withdraw such strapping from the secondary storage system 106 and pull it through the primary system 108 to the centering rollers 74. Continued clockwise motion of the carrier will pull the necessary amount of strapping from the secondary storage system 106 with the yoke 122 becoming raised as shown in Figure 6. When final tension is applied to the hoop, the solenoid 138 becomes deenergized, thus restoring the strap locking lever 130 to its binding relationship with the fixed bar 137 to clamp the strap to ensure that the previously described final pull exerted by

the carrier 16 as it moves to its terminal position will not cause any further withdrawal of strapping from the secondary system 106 but rather that such strapping will be withdrawn from the primary storing section 108. This application of final tension is a result of the motion of the carrier 16 from the position shown in Figure 7 to the position shown in Figure 8 where the carrier pulls the tensioning arm 174 upwardly against the action of the heavy compression spring 190. Immediately after the arm 174 becomes fully raised the counterclockwise motion of the hoop commences so that the carrier restores strapping to the dispenser system DS. This restored strapping is immediately taken up by lowering of the final tensioning arm as shown in Figure 9 and a subsequent lowering of the yoke 122 as shown in Figure 10. Lowering of the yoke 122 will pull sufficient strapping from the strap reel 14 into the secondary storage region of the dispensing system DS without affecting the strapping in the primary storage region 108 and store the same for the next machine cycle.

During sealing as shown in Figures 11, 12 and 13, no shifting of the carrier 16 takes place and therefore the dispenser system 164 remains stationary and assumes the position shown in Figures 10 to 13. During counterclockwise strapping, substantially the same dispenser section operations which have been described in connection with clockwise strapping takes place.

In Figures 14 and 15 a modified means for applying final tension to the loop is shown. Such means eliminates the final tensioning arm 174 and substitutes the third yoke 600 (Figure 14) which carries a single roller 601, together with a yoke abutment 602 and cable 604 (see also Figure 15) which is wrapped around a third drum 606 which is biased by a third torsion spring 608, the various drums and torsion springs being suitably mounted within a cradle 533 (Figure 15) similar to the cradle 133 of Figure 2. In view of the similarity between the modified structure of Figures 14 and 15 and the structure of Figures 1 and 2, and in order to avoid needless repetition of description, similar reference numerals of a higher order have been applied to the corresponding parts as between these two pairs of views. In the modified form of the invention of Figures 14 and 15 the final tension is effected by the downward pull of the single roller 601 on the yoke 600.

The manner in which the vibrator 22 is shiftable vertically from a lowered inoperative position to a raised operative position where it cooperates with the anvil 20 and the manner in which the anvil 20 and grippers 62 and 64 are horizontally slidable beneath the lower face of the package P are illustrated in Figures 16 and 24.

Referring to Figure 16, the frame bars 38 carry a flat support plate 200 on which there is anchored by screws 202 a fixed irregular housing, the various stationary portions of which

have been collectively designated 204 and variously clamped together by bolts 206. Still considering Figure 16 but in association with Figure 1, the frame bars 38 support a motor M2 having a double ended drive shaft 210, the front end of which is connected by a belt and pulley 212 to a jack shaft 214 which is connected by a belt and pulley 216 to a camshaft 218 by means of a single revolution clutch 217 (Figures 16 and 16a). The camshaft 218 is carried in bearings 219. The rear end of the motor shaft 210 is connected by a belt and pulley 220 to the eccentric shaft 90.

The step-up ration of the belt and pulley 220 effects a high rate of vibration on the vibrator 22 when it is in sealing cooperation with the anvil 20, as for example on the order of 6000 vibrations per minute. The step-down ratio of the two belt and pulley arrangements 212 and 216 is low so that the camshaft makes one complete rotation during each complete rotation of the hoop 18 in either direction.

Whereas the jack shaft rotates continuously, the belt and pulley 220 embodies a loose pulley 222 (Figure 16) which is freely rotatable on the eccentric shaft 90. An electrically operable clutch 224 on one side of the loose pulley 222 engages the pulley 222 and eccentric shaft 90 for rotation in unison and an electric brake 226 on the other side of the pulley 222 dampens the motion of the eccentric shaft 90. Therefore, when the clutch 224 is energized and the brake 226 is deenergized the vibrator 22 operates. When the clutch is deenergized and the brake is deenergized, the vibrator 22 will remain stationary. The clutch 224 and brake 226 are operable under the control of a switch 227.

The up and down motion of the vibrator 22, and the in and out motion of the anvil are induced under the control of a disk cam 230 (Figures 16, 17, and 18) on the camshaft 218, while motions of both the grippers 64 and 66 and of the knife or cutter 24 are induced under the control of the rear side of a double-faced cam 232 on the camshaft 218. The front side of the cam 232 controls the horizontal shifting of the two lift fingers 80 and 82.

Referring now to Figures 16 and 16a, the single revolution clutch 217 is mounted on an end of the camshaft 218 and is of a conventional spring wound type embodying the usual shaft-binding spring 236 and a stop lever 238. A solenoid 240 (Figure 16a) which is responsive to the reversing switches RS1 and RS2 is effective to momentarily release the lever 238 from the spring 236 to allow the camshaft 218 to make one complete revolution in a clockwise direction as seen in Figure 1 and in a counter-clockwise direction as seen in Figure 18.

Referring to Figure 18, the cam 230 is shown in its normal position of rest wherein a cam follower 242 rides upon a low area. The follower 242 is rotatably mounted on a pin 244 which extends across the end 246 of a shiftable inner slide 248 which has a narrow upwardly

projecting stem 250. The inner slide 248 slides in a bore 252 in an outer slide 254, while the stem 250 is guided in a reduced counterbore 256 in the slide 254. A pin 258 extends through the inner slide 248 and has its opposite ends normally bearing against a circular pressure plate 260 suspended by screws 262 from the outer slide 254. A heavy compression spring 264 is disposed in the bore 252 and encompasses the stem 250 and normally maintains the pin 258 seated against the circular plate 260. The fixed framework 204 is provided with a pair of sockets 266 which enclose a pair of hold-down springs 268 which urge the plate 260 and the outer slide 254, with its enclosed compression spring 264 and inner slide 248 downwardly and thus serve to maintain the follower 242 in engagement with the cam 230.

Still referring to Figures 16 and 18, the outer slide 254 supports the rock shaft 84 and thus the slide and rock shaft are movable vertically in unison under the influence of the cam 230. A stop 270 is secured by screws 272 in a recess which is provided in the upper slide by means of a series of shims 274. The function of the abutment 270 and shims 274 will be described presently.

During each revolution of the cam 230, as the follower 242 rides outwardly and onto the raised portion of the cam, upward motion of the roller will exert pressure upon the entire slide assembly including both the inner slide 248 and the outer slide 254, thereby raising the bearings 87 and rock shaft 84. Upward movement of the rock shaft 84 causes the slotted crank arm 85 (Figures 16, 18, and 21) to move from the lowered full line position of Figure 21 to the dotted line position. This movement of parts causes the vibrator 22 to move toward the anvil 20 which has been projected into the path of the strap. Immediately prior to engagement of the vibrator 22 with the strap, the stop 270 engages the underneath side of a thickened area 276 (Figure 18) of the anvil 20, thus terminating the upward movement of both the inner and outer slides 248 and 254. At this time the upper working end of the vibrator 22 engages the loop overlap immediately beneath the anvil as shown in dotted lines near the upper end of Figure 21 and, since the power train leading to the vibrator 22 is effective due to engagement of the clutch 224 and release of the brake 226, the vibrator 22 performs its friction-fusion operation. It will be understood of course that the pressure which is maintained by the vibrator on the loop overlap is attained by the relatively heavy spring 264 which, in addition to its precompressed force is given a further force by a slight upward shifting of the inner slide 248 as the follower roller 242 rides on the high area of the cam 230. The function of the aforementioned shims 274 is to protect the surfaces of the anvil 20 and vibrator when no strap is present between the anvil and vibrator.

The horizontal shifting movement of the

(a)

anvil 20 to bring the same into and out of the path of the strap loop is a function of the disk cam 230 by reason of a lever and pawl arrangement 280 (Figures 16, 22 and 23) including a lever 282, the outer end of which is forked so as to engage a pin 284 on the anvil 20 and which has its inner end mounted on a fixed pin 285. Clockwise movement of the lever 282 will slide the anvil 20 and withdraw it from the path of the strap loop as shown in Figure 25. A compression spring 286 nested in a recess 288 urges the lever 282 toward its anvil-projecting position. Pivoted to the lever 282 is a thrust pawl 290 which is biased in a counter-clockwise direction by a spring 292 carried on a pin 293 so that when the inner slide 248 is in its down position as shown in Figures 22 and 18, the pawl 290 overhangs an edge of the slide. As the slide 248 moves to its up position as shown in Figure 23, the pawl 290 becomes pushed out of the way and as the slide attains its upper position, the pawl 290 falls into a notch 294 in the side of the slide 248 and remains in such notch during the sealing operation. After the sealing operation a short interval of time prevails to allow the fused overlap to harden, the inner slide commences its downward motion and, in so moving, the upper side of the notch 294 brings the pawl 290 against a shoulder 296 and exerts a compressional thrust upon the pawl 290, thus swinging the lever 282 clockwise just long enough to withdraw the anvil 20 from the path of the strap loop as shown in Figure 12. Immediately thereafter, the spring 292 restores the pawl to its normal position as shown in Figures 1 and 22 preparatory to performance of a succeeding strapping cycle.

Considering now the operation of the grippers 64 and 66, and referring to Figures 16, 17, 20, 24 and 25, it has previously been pointed out that the rear side of the cam 232 (Figure 16) is effective to control the motion of both grippers. Accordingly, a lever 300 is pivoted on a shaft 302 and carries a follower 304 on its lower end which rides on a raised surface 306 on the rear side of the cam 232. The upper end of the lever projects into the confines of a cage-like gripper-actuating slide 308 (Figures 20, 24 and 25) which establishes a pair of forwardly opening large sockets 310 and a pair of rearwardly opening small sockets 312. Compression springs 314 disposed in the sockets 310 yieldingly bias the slide 308 rearwardly, thus urging the lever 300 clockwise as viewed in Figure 16 to press the follower 304 against the cam surface 306. Springs 316 disposed in the sockets 312 bear against a pair of gripper-actuating links 318, the nature of which will be set forth presently.

The grippers 64 and 66 are in the form of jaws which are pivoted together for swinging movement toward and away from each other about the axis of a fixed pin 320 (Figure 20) which has a drive fit with a socket provided in the framework 204. Each gripper is connected

to a respective link 318 by pin and slot connections 322. Forward extensions 324 on the slide 308 carry pins 326 which project through slots 328 in the links 318.

When the follower 304 (Figures 16 and 20) rides on a high spot on the cam 232, the upper end of the lever 300 will restrain the cage-like slide 308, thus compressing the springs 314 and maintaining the slide in the left hand position of Figures 20 and 25 so that the pins 326 will draw the links 318 to the left and swing the grippers 64 and 66 away from the anvil for strap-releasing purposes. Then the follower 304 rides on a low spot of the cam 232, the lever will swing in a clockwise direction and the slide member 308 will be released so that the springs 314 will shift the pins 320 to positions wherein the links 318 will force both grippers to their closed strap gripping position.

As shown in Figures 20, 24, and 25, a stop flange 330 is disposed forwardly of the pivoted grippers 64 and 66, such flange being formed on a base structure 332 which is secured to the framework by a pair of clamping screws 334. The function of the flange 330 is to act as a limit stop for the anvil 20 when the latter is projected to its advanced position and also to act as a limit stop for the forward sliding motion of the gripper assembly 64, 66.

The sliding motion of the knife 24 is effected under the control of the rear side of the double-faced cam 232 (Figure 16) and consequently under the control of the swinging movements of the follower lever 300. The details of the knife 24 are best shown in Figures 26 and 27. The knife 24 is in the form of a flat elongated rectangular steel member having identical strap severing ends in order that the knife may be reversed after one end thereof becomes dull. The medial region of the knife 24 is secured by screws 340 to the forward end of the slide 308 so that the knife moves bodily with such slide. Each end of the knife 24 has a medial strap-displacing cam surface 342 which is flanked by a pair of sharp cutting edges 344. The function of the cam surface 342 is to enter between the strap overlap and the package P so as to move the fused overlap slightly away from the anvil and allow passage of the cutting edges 344 edgewise through the strap S. The leading edge of the ramp-like cam surface 342 precedes the cutting edge by a slight dimension, thus progressively twisting the strap as the cutting action takes place to maintain the portion of the strap undergoing severing at a right angle to the cutting edges.

Referring now to Figures 16, 19, and 20, retraction of the lift fingers 80 and 82 takes place under the control of the front side of the cam 232 and the swinging movements of a lever arm 350 which is pivoted on a fixed shaft 352. The lower end of the lever arm 350 carries a follower 354 which engages a raised cam surface 355 on the front side of the cam 232. The upper end of the lever 350 receives a bar 356

3. A strapping machine for wrapping flexible strapping from a strapping source about an object at a strapping area to provide a tensioned strap loop having overlapping end portions and comprising a strap dispensing and storing mechanism, means for clamping the free end of the strapping, a circular hoop encompassing the strapping area, means for rotating the hoop, a carrier on the hoop for slip-feed engagement with the strapping between its free end and the strap dispensing and storing mechanism and effective upon rotation of the hoop to orbit the strapping area and conduct strapping around the object to produce a loop having overlapping end portions, a fixed strap guide adjacent the hoop circumference and located at a point along the path followed by the strapping between the carrier and the strap dispensing and storing mechanism for guiding strapping to the carrier, means for sealing the said overlapping end portions to each other after terminal rotation of the hoop, and means for severing the thus sealed loop from the strapping source, the strap dispensing and storing mechanism including a secondary strap storage region for receiving strapping from the strapping source and a primary strap storage region for receiving strapping from the secondary strap storage region, the primary strap storage region for receiving strapping from the secondary strap storage region, the during initial rotation of the hoop and thereafter to supply the stored strapping to the hoop through the fixed strap guide during continued rotation of the hoop, the secondary strap storage region serving to drag strapping from the source during further rotation of the hoop to provide reserve strapping for subsequent transfer to the primary strap storage region after a major portion of the strapping in the primary region has been exhausted, a releasable



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(Figures 16 and 19), having pin and slot connections 358 with a pair of spaced slidable thrust rods 360 supported in bearings 362. The front ends of the thrust rods 360 support the lower ends of the lift arms 80 and 82 so that such arms perform their swinging movements about the axes of the thrust rods 360. The two lift arms 80 and 82 are biased to the retracted rear positions of Figures 16 and 20 by means of compression springs 364 which are effective against the outer end portions of a crossbar 366 which extends through the lever arm 350. Such lift arms are individually biased to their lower positions as shown in full lines in Figures 4 to 8, 13, 17 and 19 by means of torsion springs 368 carried on the thrust rods 360 and appearing only in Figure 16.

It will be noted by reference to Figure 6 that shortly after the strap S has been wrapped around three sides of the package P it is pulled by the slip rollers 70 as indicated by the dotted line axis x-x in this view so that it rides edge-wise upwardly alongside the rear surface of the vibrator 22. At this time the edge of the strap S remote from the vibrator is confined by an upright U-shaped plate 370 (Figures 17 and 19) so that the strap progressively becomes "twisted" as indicated in Figure 16 and when it approaches the extreme upper end region of the anvil 20 the plane of the strap is at a right angle to the normal plane of the strap. Immediately after the strap rises above the level of the anvil, it is released from its confinement, and it twists to its horizontal plane directly above the vibrator 22 where it is effectively positioned between the anvil 20 and upper end of the vibrator 22 for subsequent friction-fusion purposes.

As shown in Figure 20, the framework 104 includes an upper cover plate 372 which is secured by screws 206 above the cutter knife 24.

WHAT WE CLAIM IS:

1. A strapping machine operative upon a length of flexible strapping from a strapping source for forming a closed loop about an object at a strapping area and comprising means for clamping the free end of the strapping in close proximity to the object, a hoop encircling the strapping area, a carrier on the hoop for slip-feed engagement with the strapping between its free end and the strapping source, means for rotating the hoop to orbit the carrier about the strapping area and transport the strapping about the object to form a loop having overlapping end portions, a fixed strap guide adjacent a region of the hoop circumference and located at a point along the path followed by the strapping between the carrier and the strapping source for guiding strapping to the carrier, a strap dispensing and storing mechanism interposed between the fixed strap guide and the strapping source for taking up slack in the strapping as the carrier approaches the fixed strap guide and for paying out strap-

ping as the carrier recedes from the fixed strap guide, said mechanism embodying a secondary strap storage region for receiving strapping from the strapping source and a primary strap storage region for receiving strapping from the secondary region, a releasable strap clamping device normally effective upon the strapping between the primary and secondary strap storage regions for preventing strapping from entering the primary strap storage region from the secondary strap storage region, means for releasing the strap clamping device when a major portion of the strapping in the primary strap storage region has been paid out to permit strapping to be drawn from the secondary strap storage region to the primary strap storage region, means for sealing the overlapping end portions to each other after terminal rotation of the hoop, and means for severing the thus sealed loop from strapping coming from the fixed strap guide.

2. A strapping machine as claimed in Claim 1, in which the sealing means are located substantially diametrically opposite to the fixed strap guide.

3. A strapping machine for wrapping flexible strapping from a strapping source about an object at a strapping area to provide a tensioned strap loop having overlapping end portions and comprising a strap dispensing and storing mechanism, means for clamping the free end of the strapping, a circular hoop encompassing the strapping area, means for rotating the hoop, a carrier on the hoop for slip-feed engagement with the strapping between its free end and the strap dispensing and storing mechanism and effective upon rotation of the hoop to orbit the strapping area and conduct strapping around the object to produce a loop having overlapping end portions, a fixed strap guide adjacent the hoop circumference and located at a point along the path followed by the strapping between the carrier and the strap dispensing and storing mechanism for guiding strapping to the carrier, means for sealing the said overlapping end portions to each other after terminal rotation of the hoop, and means for severing the thus sealed loop from the strapping source, the strap dispensing and storing mechanism including a secondary strap storage region for receiving strapping from the strapping source and a primary strap storage region for receiving strapping from the secondary strap storage region, the primary strap storage region for receiving strapping from the secondary strap storage region, the secondary strap storage region serving to drag strapping from the source during further rotation of the hoop to provide reserve strapping for subsequent transfer to the primary strap storage region after a major portion of the strapping in the primary region has been exhausted, a releasable

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strap clamping device normally effective upon the strapping between the primary and secondary strap storage region for preventing strapping from entering the primary strap storage region from the secondary strap storage region, and means for releasing the said strap clamping device when said major portion of the strapping in the primary region has been paid out to permit strapping to be drawn from the secondary strap storage region to the primary strap storage region.

4. A strapping machine as claimed in Claim 3, in which the object to be strapped is receivable loosely on a support surface at the strapping area, and in which the said major portion of the strapping stored in the primary strap storage region is initially drawn therefrom under light tension insufficient to effect dislodgement of the loosely supported object, and subsequently the remainder of such stored strapping is drawn off under relatively high tension during terminal rotation of the hoop immediately prior to sealing of the overlapping regions of the loop.

5. A strapping machine as claimed in Claim 3 or Claim 4, in which the primary storage region includes a first biasing means effective at all times to apply tension to the strapping between the primary storage region and the carrier and thus urge such strapping yieldingly towards a stored position within the primary storage region.

6. A strapping machine as claimed in Claim 5, in which the said first biasing means of the primary storage region includes two sets of rollers around which the strapping passes in serpentine fashion, and a first spring for yieldingly biasing one set of rollers away from the other set of rollers.

7. A strapping machine as claimed in Claim 6, in which one of the two sets of rollers is fixed while the other set is movable bodily towards and away from the said one set.

8. A strapping machine as claimed in Claim 6 or Claim 7, in which the rollers include a set of fixed upper rollers and a set of lower rollers mounted on a vertically shiftable yoke, and in which the said first spring yieldingly biases the yoke in a downward direction to urge the lower rollers away from the upper rollers.

9. A strapping machine as claimed in any of Claims 5 to 8, in which the first biasing means for yieldingly biasing the said one set of rollers exerts a relatively light tension in the strapping leading from the primary storage region to the fixed strap guide, and in which the primary storage region includes additional and normally ineffective second biasing means engageable with the strapping between the said first biasing means of the primary storage region and the said fixed strap guide, the second biasing means becoming effective to exert a relatively high tension on the strapping after the first biasing means has yielded to its maximum extent and the strap clamping device is operated to clamp

the strapping between the primary and secondary storage regions.

10. A strapping machine as claimed in any of Claims 5 to 9, in which the secondary storage region includes third biasing means effective against the strapping issuing from the source to bias and tension the same and thus yieldingly draw strapping from the source for storage in the secondary region.

11. A strapping machine as claimed in Claim 10, in which the third biasing means includes two sets of rollers around which the strapping passes in serpentine fashion, and a third spring for yieldingly biasing one set of rollers away from the other set of rollers.

12. A strapping machine as claimed in Claim 11, in which one of the two sets of rollers is fixed while the other set is movable bodily towards and away from the said one set.

13. A strapping machine as claimed in Claim 11 or Claim 12, in which the rollers include a set of fixed upper rollers and a set of lower rollers mounted on a vertically shiftable yoke, and in which the said third spring serves for yieldingly biasing the yoke in a downward direction to shift the lower rollers away from the upper rollers.

14. A strapping machine as claimed in any of Claims 3 to 13, in which the said means for releasing the strap clamping device includes means momentarily effective prior to termination of the rotation of the hoop in an initial direction for disabling the strap clamping device to permit a limited amount of strapping to enter the primary region from the secondary region.

15. A strapping machine as claimed in any of the preceding Claims, in which the source of strapping is a reel of strapping, and there is provided a strap snubbing mechanism interposed between the reel and the strap dispensing and storing mechanism for preventing over-running of the reel when strapping enters the latter mechanism from the reel.

16. A strapping machine as claimed in Claim 15, in which the reel comprises a drum on which the strapping is wound, and a pair of circular side flanges, and the strap snubbing mechanism includes an arm pivoted medially of its ends for limited rocking movement, a pair of strap guiding rollers on the opposite ends of the arm for the strapping to pass over one of the rollers and beneath the other roller, a compound roller on the arm between its pivot point and one of the rollers, the compound roller including a relatively small diameter friction roller which rides on a rim of one of the side flanges, and a relatively large diameter roller which cooperates with a pinch roller to engage the strapping therebetween, and spring means for biasing the lever in a direction to cause the small diameter roller frictionally to engage the said side flange of the drum.

17. A strapping machine as claimed in any of the preceding Claims, in which the hoop is



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rotatably supported by a series of at least three centering rollers, at least two of the centering rollers being opposed by backing rollers, one of the centering rollers constituting a friction drive roller for the hoop, and the means for rotating the hoop comprises an electric motor operatively connected to the friction drive roller.

18. A strapping machine as claimed in any of the preceding Claims, in which the means for clamping the free end of the strapping comprises a horizontally shiftable anvil normally projecting into the plane of the loop whereby, upon orbiting of the carrier, the loop is caused to encompass the anvil along with the object, and a gripper movable into and out of clamping co-operation with the anvil for releasably holding the free end of the strapping during orbital movement of the carrier, the means for sealing the overlapping end portions comprising a vibrator having a strap engaging surface designed for cooperation with a surface on the anvil to compress the loop overlap, the vibrator being movable between a position remote from the anvil and a position in close proximity to the anvil to compress the loop overlap, first cam means for shifting the vibrator between its remote position and its position of close proximity and also for retracting the anvil from the plane of the loop, means effective upon movement of the vibrator to its position of close proximity for oscillating the same relative to the anvil, and second cam means for moving the gripper into and out of clamping co-operation of the anvil.

19. A strapping machine as claimed in Claim 18, in which spring means are provided for nor-

mally urging the anvil into the plane of the loop, and in which movement of the vibrator to its position remote from the anvil under the influence of the first cam means is effective to shift the anvil out of the said plane. 40

20. A strapping machine as claimed in any of the preceding Claims, in which the means for severing the loop comprises a horizontally slidable cutter knife movable between a retracted position and an advanced position wherein it projects through the plane of the strap loop in the vicinity of the said loop overlap to sever the loop from strapping coming from the centering device, and said second cam means is effective to shift the knife between its retracted and its advanced position. 45 50

21. A strapping machine as claimed in Claim 20, in which the cutter knife is in the form of an elongated plate-like member having cutting edges at its opposite ends and is releasably secured to a slide member whereby it may be reversed when the cutting edge at one end becomes dull due to prolonged use, a ramp-like cam surface being formed on each end of the knife for entry into the space between the loop overlap and the object undergoing strapping to facilitate passage of the cutting edge endwise through the strapping at an angle relative to the plane of the strapping at the point of severance. 55 60 65

22. A strapping machine substantially as described herein with reference to the accompanying drawings. 70

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