

SPECIFICATION

A tool for constricting and closing a loop of thermoplastics strap

5 The present invention relates to automatically operated strapping tools for constricting and tensioning a loop of thermoplastics strap about a package or other article and for then sealing the overlapping segments of the strap loop with a friction fusion weld.

A number of strapping tools have been developed which join the ends of a thermoplastic strap about a package with a friction fusion weld. Additionally, 15 tools have been developed for welding two sheets of plastic together by friction. However, there remains a need for a tool that can tension a thermoplastics strap loop to a relatively high tension level, seal the overlapping strap segments with a friction fusion 20 weld, and still be relatively small, relatively light in weight, and relatively easy to operate and handle when strapping articles of various sizes and shapes.

It is an object of the present invention to provide an improved automatically operated strapping tool. 25 Advantageously, welding of the overlapping strap segments can be effected in an untensioned region of one of the overlapping strap segments. Further, in this respect, it would be desirable to provide a weld which would not longitudinally buckle either of the 30 overlapping strap segments and thus would not contribute to a loosening of the strap loop or to a weakening of the strap.

According to one aspect of the present invention, there is provided a tool for constricting and closing a 35 loop of thermoplastics strap that encircles an article and has overlapping strap segments, the tool comprising means for constricting the loop; a reversible motor for rotating initially in a first direction and then in a second, opposite direction; a drive shaft 40 driven by the motor sequentially in the first and second directions of rotation for engaging and operating the constricting means to constrict the strap loop only when the drive shaft is rotated in the first direction; sensing and control means for sensing a predetermined level of tension in the con- 45 stricted strap loop and for reversing the rotation of the motor to change the rotation of the drive shaft from the first direction of rotation to the second direction of rotation; and means responsive to 50 rotation of the drive shaft in the second direction for pressing the overlapping strap segments together after the strap loop has been constricted to the predetermined tension level and for moving one of the overlapping strap segments relative to the other 55 strap segment to effect a friction fusion weld of the overlapping segments.

According to a second aspect of the invention there is provided an all-electrically operated tool for tensioning and sealing a loop of thermoplastics 60 strap that encircles an article and has first and second overlapping strap segments, the tool comprising a frame; a first shaft mounted for rotation about its longitudinal axis relative to the frame, the first shaft defining a bore having a longitudinal axis 65 concentric with the longitudinal axis of rotation of

the first shaft; an electrically operated, reversible motor carried by the frame for rotating the first shaft sequentially in a first direction and then in a second, opposite direction; a second shaft having one end in the bore of the first shaft and mounted for rotation about its longitudinal axis relative to the frame; a tensioning means mounted on the frame for initially gripping the first overlapping segment of the strap and moving the strap to tension the loop; transmission means drivably connecting the second shaft with the tensioning means; at least one one-way clutch within the bore of the first shaft for engaging the first and second shafts to permit rotation of the second shaft with the first shaft in the first direction 70 to tension the strap loop and to permit the first shaft to rotate in the second direction without effecting a rotation of the second shaft; means for sensing a predetermined level of tension in the strap loop; control means responsive to the loop tension sensing means for reversing the rotation of the motor 75 from the first direction of rotation to the second direction of rotation when the predetermined loop tension level is sensed by the tension sensing means; means responsive to the rotation of the first 80 shaft in the second direction for pressing the first and second overlapping strap segments together after the strap loop has been tensioned to the predetermined level; and oscillating drive means on the first shaft for oscillating the strap pressing 85 means to move the first overlapping strap segment generally transversely of the strap length relative to the second overlapping strap segment to effect a friction fusion weld of the overlapping segments.

Thus, the tool of the present invention may be 100 relatively light in weight and compact, so that the tool may be readily manipulated and used for extended periods of time without tiring the user. Preferably, the tool is electrically operated. The tool preferably also automatically continues to effect a 105 friction fusion weld of the overlapping strap segments and severs the trailing portion of the strap from the strap loop. A saw blade mechanism may be provided for cutting the trailing portion of the strap loop before or as the weld is being effected.

The invention may be carried into practice in various ways and two embodiments will now be described by way of example with reference to the accompanying drawings in which:-

115 *Figure 1* is a side elevation of the tool of the present invention, with the tool being illustrated upon an article in a tension drawing position and with portions of the structure broken away in sections;

Figure 2 is a fragmentary front elevation, partially cut away to show interior details of the apparatus illustrated in *Figure 1*;

Figure 3 is an enlarged, fragmentary, cross-section taken generally along the planes 3-3 in *Figure 2* showing the tool in a strap loading position;

125 *Figure 5* is a view similar to *Figure 3* but showing the tool in a tensioned and sealing position;

Figure 5 is a fragmentary, cross-section taken generally along the plane 5-5 in *Figure 3*;

Figure 6 is a fragmentary, cross-section of the saw blade area of the tool illustrated in *Figure 5* showing 130

the upper overlapping strap segment being pressed against the saw blade;

Figure 7 is a fragmentary, cross-section taken generally along the plane 7-7 in Figure 4;

5 Figure 8 is a fragmentary cross-section taken generally along the various planes 8-8 in Figure 4;

Figure 9 is a fragmentary, cross-section taken generally along the plane 9-9 Figure 7;

10 Figure 10 is a view similar to Figure 9 but showing the strap pressing member being moved in the direction opposite to that in Figure 9;

Figure 11 is a fragmentary, cross-section of the release ring and pawl mechanism illustrated in Figure 5, but with the first drive shaft rotating in the direction opposite to that illustrated in Figure 5.

15 Figure 12 is a fragmentary, cross-section similar to Figure 3 but showing the tool with a second embodiment of a saw blade and with the pressing member and saw blade in the elevated, strap-receiving position;

Figure 13 is a fragmentary view similar to Figure 8, but showing the tool of Figure 12 with the second embodiment of the saw blade;

25 Figure 14 is a view similar to Figure 5 but showing the tool of Figure 12 with the second embodiment of the saw blade in the elevated position; and

Figure 15 is a view similar to Figure 7 but showing the tool of Figure 12 with the second embodiment of the saw blade in the lowered position.

30 A tool in accordance with the present invention is illustrated generally at 20 in Figure 1 and is shown seated upon a package P which is represented with a loop of strap S encircling it and having a first or upper overlapping segment U and a second or lower overlapping strap segment L threaded through the tool. The upper or first overlapping strap segment U may lead from a suitable supply reel not shown. As the upper strap segment U extends beyond the second or lower overlapping strap segment L, it can be said to comprise a standing or trailing portion T of the strap S.

The main framing structure of the tool 20 consists of a sealer housing 28 with a base 30, a gear box 32 (Figure 2), a motor enclosure 34 bolted to the sealer housing 28 with bolts 35, a handle assembly 36, and associated supporting and connecting pieces. The framing structure and housing may comprise a number of pieces, wall sections, and plates which fit together and are joined by suitable means, such as with bolts and/or screws. Preferably the frame and housing pieces are adapted to be easily removed to allow access to particular interior regions of the tool for the purposes of routine inspection and/or periodic maintenance of the mechanisms within those regions.

In operation, the tool 20 is applied to an already formed strap loop by inserting the overlapping segments U and L of the strap loop into the tool 20 as illustrated in Figure 1. Subsequently, the tool 20 is activated to automatically constrict and tension the strap loop tight around the package P to a predetermined tension level whereupon the tool 20 subsequently and automatically severs the trailing portion T of the strap S from the loop and joins the overlapping strap segments U and L with a friction

fusion weld.

Motor and drive shaft assembly

The motor and shaft assembly will be described with reference now to Figures 1, 2, 8 and 9. A reversible, electric motor 40 is mounted within the motor housing 34 by suitable bolts 36 (Figure 8). The motor 40 has a rotating armature and shaft assembly 42 supported at one end in bearing 44 (Figure 1) in the motor housing 34 and at the other end in bearing 46 (Figure 8) which is mounted in a wall portion 330 of the sealer housing 28. A cooling fan 48 is mounted on the armature shaft 42 just inwardly of bearing 46. Power to the motor is introduced through the motor housing 34 by means of the electric cord 50 (Figure 1).

With reference now to Figure 9, the motor armature and shaft assembly 42 is seen to include a (first drive shaft means or) first drive shaft 60 which rotates about the longitudinal axis of the armature shaft 42 and which defines a receiving bore 64 at one end.

A second shaft 70 is mounted at one end within the receiving bore 64 of the first shaft 60 and is mounted for rotation relative to the first shaft 60 by means of suitable needle bearings 72 and 74. Forward of the needle bearing 72 (to the left of needle bearing 72 as viewed in Figure 9) a rubber grease seal 84 may be employed to protect the bearing.

A pair of one way clutches 76 and 78 are disposed within the two needle bearings 72 and 74 in the annular region defined between the first shaft 60 and the second shaft 70. The driving portion of each clutch 76 and 78 is secured to the first shaft 60 for rotation therewith. During strap loop tensioning the one way clutch mechanisms 76 and 78 permit the first shaft 60 to drive the second shaft 70 in a first direction of rotation. However, the clutches permit the first shaft 60 to rotate in the second, opposite direction during friction fusion welding of the overlapping strap segments without effecting a rotation of the second shaft 70 in that second direction.

Two clutches 76 and 78 are incorporated only for purposes of power transmitting capability. A single clutch of sufficient load transmitting capability could be used.

Any suitable one way clutch mechanism may be employed for the clutches 76 and 78, such as the type that has the form of a plurality of inwardly facing clutch teeth which trap cylindrically shaped rollers therebetween and wherein the teeth are shaped to allow the outer, first shaft 60 to rotate freely in one direction but bind the rollers against the inner, second shaft 70 when the outer, first shaft 60 is rotated in the opposite direction thereby causing both shafts to rotate together.

The portion of the second shaft 70 projecting from the first shaft 60 passes through a suitable support wall 86 associated with the housing or frame of the tool. The support wall 86 carries a one way clutch 88, similar to clutches 76 and 78, but oppositely acting from clutches 76 and 78, to positively prevent rotation of shaft 70 relative to support wall 86, and hence relative to first shaft 60, in the second

direction of rotation. A grease seal 90 is retained in support wall 86 provided between the first shaft 60 and the clutch 88.

- On the distal end of the second shaft 70, and integral therewith, is a drive pinion gear 92. The drive pinion gear 92 is operable, through a transmission means described hereinafter, to operate the mechanism for constricting the strap loop to a predetermined tension level.

10 *Transmission and tensioning wheel*

- With reference now to Figures 2 and 8 in particular, the drive pinion gear 92 is seen to project into the gear housing 32 which houses a gear transmission comprising a shaft 100 mounted in gear housing 32 on one end by means of a roller bearing assembly 102 and on the other end of the gear housing 32 by means of a roller bearing assembly 104. A ring gear 106 is fixed to the shaft 100 for rotation therewith and is in engagement with drive pinion gear 92. Also secured to shaft 100 is a spiroid worm gear 108. Another shaft 112 is mounted generally perpendicular to shaft 100 across the gear housing 32 by means of a ball bearing assembly 114 at one end. A gear 120 is fixed to shaft 112 for rotation therewith and is engaged with the spiroid worm gear 108. The gear 120 has a reduced diameter portion 122 which is mounted within a bearing 124 at one end of the gear housing 32.

- The shaft 112 projects from the gear housing 32 (to the right as viewed in Figure 2) and extends to the exterior of the gear housing 32 where it carries a tension wheel 126 which is keyed to shaft 112 for rotation therewith. With reference to Figures 1, 2, 3 and 4, it is to be noted that the tension wheel 126 rotates in a counterclockwise direction during the loop constricting or tensioning step when the motor 40, and consequently first shaft 60 and second shaft 70, are rotated in the first direction (shaft 70 rotating clockwise as viewed in Figure 2). This pulls the upper overlapping strap segment U to the right, as viewed in Figure 1, to constrict the loop S and apply tension to the loop.

45 *Tension sensing mechanism*

- With reference to Figures 3, 4 and 8, a tension arm 130 is shown pivotally mounted about a shaft 132, which shaft 132 is mounted at each end in the tool housing. The tensioner arm 130 has a lower arm 140 extending alongside the tension wheel 126 and an upper arm 142 extending above the tension wheel 126. The lower arm 140 of the tension arm 130 carries an anvil 146 which is adapted to contact the lower strap segment L as illustrated in Figure 4.
- The upper arm 142 of the tensioner arm 130 carries a tension sensing limit switch 150 having a contact member 152 projecting upwardly from the arm 142.

- The tension sensing switch 150 is part of a control circuit (not illustrated) associated with the electric motor 40 for reversing the rotation of a motor from the first direction (during which the tension wheel 126 is rotated counterclockwise as viewed in Figure 1 to tension the strap loop) to the second, opposite direction for effecting a friction fusion weld at the

overlapping strap segments as will be described in detail hereinafter.

- A spring plate 154, having a generally L-shaped configuration as best illustrated in Figure 8, is mounted to the top of the upper arm 142 and is bent outwardly as best illustrated in Figure 3 so that the underside of the spring plate 154 just touches the switch contact member 152 but does not urge contact member 152 downwardly to actuate the switch 150. The spring plate 154 is secured to the upper arm 142 by suitable screws 156 and 158.

- A roller 160 is mounted at the distal end of the upper arm 142 for rotation about a shaft 162 carried by the upper arm 142.

- The tension arm 130 is biased about its mounting shaft 132 in a counterclockwise direction, as viewed in Figure 3, by a torsion spring 166 which is secured at one end about a lug 168 projecting from the tool housing and at the other end to a lug 170 projecting from the upper arm 142. Under the urging of the spring 166, the tension arm 130 rotates to press the overlapping strap segments U and L against the tension wheel 126 as illustrated in Figure 1. During the tensioning sequence, the tension wheel 126 rotates in a counterclockwise direction, as viewed in Figure 1, so that the upper overlapping strap segment U is gripped by the tension wheel 126 and moved or pulled to the right (as viewed in Figure 1) to constrict the strap loop S and to tension the loop about the package P.

- Owing to the relative location of the tension arm shaft 132 and the tension wheel shaft 112, the tension arm 130 is self-energized during the tensioning process to rotate further in a counterclockwise direction about the shaft 132 and to press against the overlapping strap segments U and L with increasing force. As the overlapping strap segments U and L are pressed together between the anvil 146 and the tension wheel 126 during tensioning, the strap segments U and L compress to some degree and this permits the tension arm 130 to rotate even further in a counterclockwise direction about shaft 132. In addition, anvil 146 preferably has a plurality of teeth (not illustrated) which grip and penetrate, to some extent, the lower surface of the lower overlapping strap segment L. As the tension level increases, the teeth on the anvil 146 sink further into the lower strap segment L.

- This strap compression and penetration by the anvil 146, of course, aids in preventing the tension wheel 126 from slipping relative to the upper strap segment U. However, this action has the further effect of rotating the arm 130 further about shaft 132 to move upper arm 142 and so switch 150. To this end, an abutment means, such as set screw 180 is provided in the tool housing above switch 150. When a predetermined tension level is reached, the compression level of the overlapping strap segments U and L and the degree of penetration of the anvil teeth into the lower strap segment L is sufficient to force the spring plate 154 and actuating member 152 on switch 150 against the set screw 180 to actuate the switch 150 as illustrated in Figure 4. At any tension below the predetermined tension level, the amount of compression of the overlapping strap

segments and the degree of penetration of the anvil teeth into the lower strap segment L is not enough to force the switch 150 against set screw 180 to actuate the switch.

- 5 The predetermined tension level can be varied by adjusting the set screw 180. If the set screw 180 is adjusted so that it projects closer to the switch 150 than shown in Figure 3, then the tension level at which the switch 150 is actuated will obviously be
- 10 less. Conversely, if the set screw 180 is adjusted so that it is farther from switch 150 than is illustrated in Figure 3, the tension level at which switch 150 is actuated will be greater.

The spring plate 154 is mounted in the position 15 illustrated in Figure 3 and is not intended to be adjustable. The spring plate 154 merely serves to absorb impact energy on the switch actuating member 152, and hence on the switch 150, should the strap loop S break during tensioning.

- 20 An operating lever assembly 184 is provided for swinging the tension arm 130 away from the tension wheel 126 to allow the overlapping strap segments U and L to be inserted between the anvil 146 and the tension wheel 126. Operating lever assembly 184
- 25 has an operating lever 186, as best illustrated in Figure 1, and an operating lever cam 188 which has a cam surface 189 adapted to engage roller 160 at the distal end of upper arm 142 on the tension arm 130.

The operating lever assembly 184 is rotatably 30 mounted relative to the tool frame about shaft 190. The operating lever assembly 184 is biased upwardly (counterclockwise about shaft 190 as viewed in Figures 1, 3 and 4) by torsion spring 94 coiled around shaft 190. One end 196 of torsion spring 194 is

35 anchored relative to the tool housing and the other end 198 of torsion spring 194 is received in an aperture 200 in the lever cam 188 to urge the operating lever assembly 184 counterclockwise as viewed in Figure 1.

- 40 In the uppermost position, the operating lever assembly 184 is out of contact with the tension arm roller 160 so that the tension arm 130 is free to depress the overlapping strap segments U and L against the tension wheel 126 as illustrated in Figure
- 45 1. When the operating lever 186 is pushed downwardly by the tool operator, the cam surface 189 of the operating lever cam 188 engages the roller 160 and urges the tension arm 130 in a clockwise direction about the shaft 132 to move the anvil 146
- 50 away from the tension wheel 126 to allow the insertion of the overlapping strap segments U and L therebetween as illustrated in Figure 3.

Weld gripper pads and oscillating drive means

- 55 After the strap loop has been constricted about the package P and tensioned to the predetermined tension level, the rotation of the motor 40 is reversed and a pressing member or gripping weld member, such as upper gripper pad 206, is urged against the
- 60 top surface of the upper overlapping strap segment U and is oscillated to move the upper strap segment U rapidly relative to the lower strap segment L as best illustrated in Figures 4, 6, 9 and 10. Specifically, as is most clearly illustrated in Figures 5 and 10, an
- 65 upper gripper pad 206 is disposed above the over-

lapping strap segments U and L. Pad 206 is movable between an elevated position illustrated in Figures 3 and 5 where it is out of contact with the upper strap segment U and a lowered position illustrated in

- 70 Figures 4 and 7 where it is in contact with the upper strap segment U. In the lowered position illustrated in Figures 4 and 7, the upper gripper pad 206 forces the upper strap segment U against the lower strap segment L.

75 The upper gripper pad 206 preferably has a serrated strap engaging surface, or a plurality of teeth, gripping the upper surface of the upper overlapping strap segment U. The gripper member 206 is mounted to, or is integral with, a frame 212, which frame 212 is mounted to, or is integral with, a ring 214 at one end. The ring 214 is disposed about the first shaft 60. Preferably, a needle bearing 216 is press-fitted to the inside of the ring 214 to allow the ring to easily rotate relative to the shaft 60.

- 85 With reference to Figures 9 and 10, it can be seen that shaft 60 has a reduced diameter eccentric portion presenting a generally cylindrical drive surface 220 oriented about a longitudinal axis which is parallel to, but displaced from, the coincident longitudinal axes of the shaft 60, of the receiving bore 64 and of the second shaft 70. Thus, as the shaft 60 is rotated, the driven ring 214 is carried in a circular orbit about the longitudinal axis of the shaft 60. Owing to the fact that the ring 214 and bearing 216
- 90 secured to ring 214 permit rotation of the eccentric portion of shaft 60, the frame 212 and upper gripper pad 206 can be maintained in the relative positions shown in Figures 5 and 6, subject to the oscillating motion in the directions transverse to the length of the strap segments U and L as indicated by the double headed arrow 226 in Figures 5 and 6.

It is to be noted that the oscillation of the pad 206 transversely of the overlapping strap segments U and L occurs during the tensioning sequence when the motor 40 is being rotated in the first direction (clockwise as indicated by arrow 228 in Figure 5) when the gripper pad 206 is in the raised position and out of engagement with the overlapping strap segments as well as when the motor 40 is rotated in the second direction (counterclockwise as indicated by arrow 230 in Figure 7) during the strap welding sequence and when the upper gripper pad 206 is pressing against the overlapping strap segments U and L.

- 115 As illustrated in Figures 9 and 10, a balance weight 227 is provided on the fan assembly 48, rotated 180 degrees out of phase with respect to the apogee of the eccentric portion 220 of the drive shaft 60. This provides an overall balanced assembly.

Strap pressing mechanism

- 120 A means or mechanism responsive to the rotation of the first shaft 60 in the second direction (during the welding sequence) is provided for pressing the overlapping strap segments together after the strap loop has been constricted to the predetermined tension level and for moving at least one of the overlapping strap segments relative to the other strap segment to effect a friction fusion weld of the
- 130 overlapping segments.

Specifically, with respect to Figures 4, 5, 7 and 8, the pressing means or mechanism is seen to include the pressing member or upper gripper pad 206 which is adapted to contact the top surface of the upper overlapping strap segment U. The upper gripper pad 206 is moved between the first, elevated position out of contact with the upper overlapping strap segment U and the second, lowered position in contact with the upper overlapping strap segment U by means of a linkage system comprising a pair of first links 302 and 304 and a rocker arm 306. The links 302 and 304 are pivotably connected at their lower ends to upper gripper pad 206 by means of pin 308 and to rocker arm 306 at their upper ends by means of pin 310.

Rocker arm 306 has a first end portion 309, a second end portion 311, and an integral shaft 312 which is rotatably mounted at one end in a wall portion 324 of gear housing 32 in receiving bore 314 and at the other end in a wall portion 329 of motor housing 34 in receiving bore 316. A pair of torsion springs, left rocker arm torsion spring 318 and right rocker arm torsion spring 320, are mounted about the shaft 312 to bias the shaft in the clockwise direction as viewed in Figures 5 and 6. To this end, spring 318 has an end portion 322 engaged with wall portion 324 of the gear housing and another end portion 326 engaged with the rocker arm first end portion 309. Similarly, the right rocker arm torsion spring 320 has a first end portion 328 engaged with wall portion 329 of the motor housing and another end portion 332 engaged with the rocker arm second end portion 311. In this manner, the rocker arm 306 is continuously biased to urge the pair of links 302 and 304 downwardly to force the upper gripper member 206 against the top surface of the upper overlapping strap segment U as illustrated in Figure 7.

As illustrated best in Figure 5, a release pawl 336 is pivotably mounted about a pin 338 to the wall portion 330 of the sealer housing 28 for holding the rocker arm 306 against the bias torque of springs 318 and 320. To this end, the rocker arm 306 has a short outwardly projecting leg 340 on the rocker arm first end portion 309 and the release pawl 336 has a cut-out notch 342 (best illustrated in Figure 7) for receiving the leg 340 and functioning as a latch means for engaging the rocker arm 306 to hold it in the orientation illustrated in Figure 5 wherein the upper gripper pad 206 is in the first, elevated position out of contact with the strap. To hold the release pawl 336 in the position illustrated in Figure 5 wherein the rocker arm 306 is engaged, a release pawl spring 344 is provided and has a first end portion 346 engaging the release pawl 336 and a second end portion 348 (best viewed in Figure 8) secured to wall portion 330 of sealer housing 28. Thus, spring 344 urges the release pawl 336 about shaft 338 in a counterclockwise direction (as viewed in Figure 5) to engage the rocker arm 306.

The release pawl 336 is moved in a clockwise direction about shaft 338 (as viewed in Figure 7) to release and disengage the rocker arm 306 by means of a release ring 350 disposed about shaft 60. As best illustrated in Figures 10 and 11, a release ring clutch

354 is disposed between the shaft 60 and release ring 350. The clutch 354 is a one way clutch similar to the one way clutches 76 and 78 between the first shaft 60 and the second shaft 70 previously described and illustrated in Figure 9.

With reference to Figure 11, the one way clutch 354 is seen to comprise a plurality of roller pins 356 and an outer driven member 358 having teeth 360 adapted to be bound by the rollers 356 when the first shaft 60 is rotated in the counterclockwise direction (indicated by arrow 362 in Figure 11) so that the driven clutch member 358 rotates counterclockwise also with the first shaft 60 to rotate the release ring 350 in the counterclockwise direction.

When the motor 40 and shaft 60 are rotated in the first direction to constrict the strap loop (clockwise as indicated by arrow 228 in Figure 5) the release ring clutch 354 disengages the release ring 350 from the drive shaft 60 so that the drive shaft 60 rotates in that first direction without rotating the release ring 350.

The release ring 350 defines a circumferentially interrupted groove or pair of peripheral grooves 372 and 374 which are separated by wall portions or lugs 376 and 378. The release pawl 336 is adapted to engage one of the lugs 376 and 378 by means of a plunger 380 projecting downwardly from the release pawl 336. The plunger 380 is received in the lower end of a bore 382 within release pawl 336. A plug 384 is retained in the upper end of bore 382 by means of a press fit. A compression spring 386 is disposed within the bore 382 between the plug 284 and the top of the plunger 380 to bias the plunger 380 downwardly into one of the grooves 372 and 374 defined in the release ring 350. The plunger bore and spring structure cooperate with the tool reset mechanism in a manner explained hereinafter in the section entitled "Reset Mechanism".

With reference to Figure 5, when the motor 40 rotates the shaft 60 in the clockwise direction indicated by arrow 228 to constrict and tension the strap loop, the release ring 350 is not driven by the shaft 60 because the clutch 354 is disengaged in that direction of rotation. To the extent that there is some transmission of rotational friction forces from the drive shaft 60 through the clutch 354 to the release ring 350, the release ring 350 may be rotated in the clockwise direction until a lug, say 376, abuts the downwardly projecting plunger 380. However, since the clutch is not engaged to drive the release ring 350, the lug 376 is only lightly forced against the plunger 380, thus stopping the further rotation of the release ring 350 while the drive shaft 60 continues to rotate.

When the strap loop S has been constricted about the package P and the direction of the motor is reversed to begin the welding sequence, the shaft 60 rotates in the counterclockwise direction indicated by arrow 362 in Figure 11. The clutch 354, now engaging the release ring 350 with the drive shaft 60, causes the release ring 350 to rotate with the drive shaft 60 in the counterclockwise direction to bring one of the lugs, say lug 378, against the side of plunger 380. Since only the side of the plunger 380 is contacted by lug 378, the plunger is not forced

upwardly in the bore 382 of the pawl 336, but is forced laterally out of the release ring groove 372. This causes the release pawl 336 to overcome the bias of the torsion spring 344 and to rotate in the clockwise direction about the shaft 338 to thereby disengage the rocker arm leg 340 from the release pawl latch means or notch 342. Upon disengagement from the release pawl 336, the rocker arm 306 is rotated about shaft 312 by the torsion springs 318 and 320 (in the clockwise direction as viewed in Figure 7) to force the upper gripper member 206 against the overlapping strap segments.

The release pawl 336 is maintained out of contact with the still rotating release ring 350 by the unlatched rocker arm 306. To this end, the release pawl 336 has a camming surface 388 against which rocker arm leg 340 slides to its upwardmost position (Figure 7).

The cam surface 388 of the release pawl 336 is thus engaged by the rocker arm leg 340 to hold the release pawl outwardly against the biasing force of the torsion spring 344 and to maintain the release pawl plunger 380 out of engagement with the rotating release ring 350.

Although only one release ring lug would be required, two release ring lugs 376 and 378 are provided for balance purposes since the release ring 350 rotates along with the drive shaft 60 in the second direction of rotation during the strap welding sequence.

It is to be remembered that the gripper member 206, being mounted to the oscillating drive ring 214 on the drive shaft 60, is continuously reciprocating in the direction transverse to the strap length as indicated by arrow 226 in Figure 7. As the overlapping strap segments U and L are forced together by the reciprocating upper gripper pad 206, the segments are friction fused together to form the joint (seal) in the strap loop.

With reference to Figure 7, it can be seen that as upper gripper pad 206 reciprocates in the direction of arrow 226, it is also tilted upwardly, relative to the flat surfaces of the strap, by the action of the oscillating ring 214. To accommodate this slight tilting effect of the upper gripper pad 206, and to ensure that the strap segments are pressed together with relatively uniform pressure, a movable lower gripper pad 400 is provided below the strap segments U and L. Pad 400 has a serrated or toothed surface (not illustrated) adapted to contact the bottom surface of the lower overlapping strap segment L. The lower gripper pad 400 is mounted within a notch 401 in base 30 of the tool 20 on top of a resilient support pad 402. The support pad 402 is preferably made of 50 durometer urethane. Thus, when the upper gripper pad 206 is tilted upwardly slightly by the action of the oscillating ring 214, the resilient pad 402 permits the entire sandwich configuration of the overlapping strap segments U and L and the lower gripper pad 400 to tilt with the upper gripper pad 206.

Strap severing mechanism

As best illustrated in Figures 5, 6, 7, 8, 9, and 10, a saw blade 410 is provided just rearwardly of the

lower gripper pad 400. As best illustrated in Figures 5 and 7, the saw blade 410 is pivotably mounted about a pin 412 to the tool housing and has a plurality of upwardly projecting saw teeth 414 which are adapted to contact the bottom surface of the upper overlapping strap segment U and cut through that upper strap segment as the upper strap segment is forced downwardly against the lower strap segment L by the upper gripper member 206 at the beginning of the welding sequence. To this end, when the strap loop is formed about the package P and when the overlapping strap segments U and L are placed in the machine as illustrated in Figure 1, the trailing portion T of the strap is placed over the top of the saw blade 410 while the lower overlapping strap segment L is placed beneath the saw blade 410.

The saw blade 410 is preferably mounted on pin 412 to permit sliding of the saw blade parallel to shaft 60 forwardly or rearwardly relative to the upper and lower gripping pads 206 and 400, respectively. The saw blade 410 is maintained in a given position relative to the upper gripper pad 206 by extensions of frame members 212 which define notches 420 (Figure 4) in which a rear portion 422 of the saw blade 410 is slidably disposed. Thus, the frame 212 (and upper gripper pad 206) can oscillate in the direction of the arrow 226 (Figures 5 and 6) relative to the saw blade 410. However, any movement of the frame 212 forwardly or rearwardly in the tool (parallel to the drive shaft 60) will carry the saw blade 410 forwardly or rearwardly with the frame 212.

Reset mechanism

After the overlapping strap segments have been sealed together by the friction fusion weld, the tool may be reset to raise the upper gripper pad 206 to the first elevated position out of contact with the overlapping strap segments to permit the tool to be removed from the sealed strap loop and to be used again to tension and seal another strap loop about the same package or about a different package.

As shown in Figures 4 and 5, the operating lever cam 188 of the operating lever assembly 184 is adapted to actuate a reset link 450 which is engaged with the rocker arm 306. With reference to Figure 4, the operating lever cam 188 is seen to be oriented in its normally, spring-biased position out of contact with the tension arm 130 whenever the overlapping strap segments U and L are being joined by a friction fusion weld. The operating lever cam 188 defines an arcuate guide slot 454 for receiving an L-shaped upper end portion 455 of the link 450.

The link 450 has another end portion 456 which is C-shaped and is engaged with the rocker arm first end portion 309 as best illustrated in Figures 7 and 8. Specifically, the first end portion 309 of the rocker arm 306 has an extension 460 defining a bore 462 through which the link end portion 456 passes and by means of which the link 450 is secured to the rocker arm 306.

When the rocker arm 306 is in the orientation illustrated in Figure 7 during the friction fusion welding sequence, the reset link 450 is urged to its

upwardmost position by the rocker arm 306 so that the upper end 455 of link 450 (Figure 4) is positioned near the top of the operating lever guide channel 454. The operating lever assembly 184 is of course normally biased upwardly and is thus out of contact with the tension arm roller 160 as clearly illustrated in Figure 4.

After the friction fusion weld has been completed and the motor deenergized, the tool may be removed from the sealed strap loop by pressing the operating lever 186 downwardly. This causes the anvil 46 to swing away from the tension wheel 126 and causes the reset link 450 to be urged downwardly in the direction of arrow 466 in Figure 5 to bring the leg 340 of the rocker arm 306 into engagement with the latch means 342 on the latch pawl 336.

As the release pawl 336 rotates back into engagement with the leg 340 on the rocker arm 306, the plunger 380 enters one of the grooves 372 or 374 (Figure 11) of the release ring 350. Since the motor is deenergized, the release ring 350 and the shaft 60 will have stopped their rotation. The release ring lugs 376 and 378 (Figure 11) could be oriented in any position. If one of the lugs had stopped right below the point where the plunger 380 swings into the release ring grooves 372 or 374, the plunger 380 would hit that lug. However, the compression spring 386 is designed to permit the plunger 380 to be forced upwardly by the lug as the release pawl 336 rotates counterclockwise about shaft 338 under the biasing force of torsion spring 344. This ensures that the release pawl 336 will always come down to the normal latched position in engagement with the leg 340 on rocker arm 306 when the tool is reset by the downward movement of link 350 in response to the downward movement of operating lever assembly 184.

Since the downward movement of the operating lever assembly 184 is necessary to pivot the tension arm 130 away from the tension wheel 126 to release the overlapping strap segments, it is seen that the tool is automatically reset whenever the tool is removed from the sealed strap loop.

When the tool 20 is next engaged with overlapping strap segments of a new strap loop (as illustrated in Figure 1), the operating lever assembly 184 is, of course, biased by the spring 194 in the counterclockwise direction about shaft 190 so that the upper end of reset link 450 assumes a position near the bottom of the guide channel 454. The length and shape of the guide channel 454 is such that the reset link 450 is not pulled upwardly by the cam segment 188 during the tensioning process. Thus, the link 450 exerts no force upon the rocker arm 306.

As best illustrated in Figure 2, a convenient momentary contact button 500 is provided in the side of the tool housing to actuate contact member 502 of a cycle starting switch 504. The cycle starting switch 504 is part of the overall control circuit for operating the electric motor 40 and a friction fusion weld sequence timer (not illustrated). The friction fusion weld sequence timer is actuated when the motor 40 reverses from the first direction of rotation (during tensioning) to the second direction of rotation (during welding) and operates the motor for the

predetermined period of time necessary to achieve a good friction fusion weld in the overlapping strap segments.

Should the reset mechanism accidentally fail and release the upper gripper pad 206 from the elevated position after removal of the welded strap from the tool, an abutment member, such as screw 520 (Figures 5 and 7) is provided in the housing side wall portion 530 to limit the downward travel of the rocker arm 306 and hence, of the upper gripper pad 206. The rocker arm 306 would come to rest on the end of screw 520 and prevent the upper gripper pad 206 from contacting the lower gripper pad 400. This eliminates the possibility of damaging the teeth on either or both gripper pads.

Sequence of operation

Although the operation of the tool 20 is believed to be easily understood from the description of the various mechanisms comprising the tool presented above, a brief summary of the sequence of operation will be given here for completeness.

The tool 20 is initially placed against the surface of a package P as illustrated in Figure 1 and the operating lever 186 is pushed downwardly to swing the tension arm 130 outwardly away from the tension wheel 126. The strap is placed around the package P with overlapping strap segments U and L inserted between the anvil 146 of the tension arm 130 and the tension wheel 126. The operating lever is then released so that the tension arm 130 is pivoted to force the anvil 146 against overlapping strap segments U and L and press them against tension wheel 126.

Of course, as the operating lever 186 is pushed downwardly when the overlapping straps are inserted into the tool, if for some reason the tool had not been previously reset, the reset link 450 will be moved downwardly. This urges the rocker arm 306 (Figure 5) into engagement with the latch notch 342 of the release pawl 336 and this raises the upper gripper pad 206 to the elevated position out of contact with the strap segments.

The pressing of button 500 (Figure 2) actuates the control system of the tool 20 and the motor 40 begins to rotate in the first direction (clockwise with reference to Figure 2) to rotate the shaft 60 and, through clutches 76 and 78, shaft 70 and pinion 92 in the clockwise direction.

The pinion 92 on the end of the second shaft 70 rotates the ring gear 106 which rotates shaft 100 to rotate spiroid worm gear 108. Gear 120, engaged with spiroid worm gear 108, is thus driven to rotate shaft 112 to turn the tension wheel 126 in the counterclockwise direction as viewed in Figure 1 to pull the upper overlapping strap segment U relative to the lower overlapping strap segment L for constricting the strap loop S about the package P and to tension the loop.

As tension is pulled in the strap loop, the self-energizing action of the tension arm 130 forces the anvil 146 further towards the tension wheel 126 as the straps compress between the wheel 126 and the anvil 146 and as the teeth of the anvil 146 dig into the bottom strap segment L. This causes the tension arm

130 to rotate slightly further in the counterclockwise direction about shaft 132 to swing the tension sensing switch 150 against the screw 180 to actuate switch 150 at the predetermined tension level. This
 5 reverses the rotation of the motor 40. Owing to the clutch 88 (Figures 9 and 10), the second shaft 70 is prevented from rotating back in the direction that would tend to loosen the strap tension.

When the rotation of shaft 60 is reversed from the
 10 first direction to the second direction, the release ring clutch 354, previously disengaged, engages the release ring 350 with the shaft 60 so that the shaft 60 rotates the release ring 350 in the second direction (counterclockwise as indicated by arrow 362 in
 15 Figure 11).

Rotation of the drive shaft 60 and release ring 350 in the second direction causes one of the release ring lugs (e.g., lug 378) to pivot the release pawl 336 to unlatch the rocker arm 306. As illustrated in Figure 7,
 20 the rocker arm 306 then pivots in a clockwise direction (arrow 600) with its shaft 312 to force the upper gripper pad 206 downwardly against the top surface of the upper overlapping strap segment U.

Owing to the rotation of the eccentric surface 220
 25 of shaft 60, the drive ring 214 oscillates in a circular path in the direction of arrow 602 illustrated in Figure 7 and thus imparts an oscillating motion to upper gripper pad 206. Owing to the restraint of the rocker arm 306 which transmitted through links 302 and 304
 30 to the upper gripper pad 206, upper gripper pad 206 is primarily reciprocated in a direction indicated by arrow 226 in Figure 7. This direction is transverse to the length of the overlapping strap segments U and L. The upper overlapping strap segment U, which is
 35 gripped by the gripper pad 206, is thus moved transversely with respect to the lower overlapping strap segment L to form a friction fusion weld.

During this reciprocating movement, the upper gripper pad 206 tends to tilt upwardly (on the left end
 40 of the pad as viewed in Figure 7) because of the small upward oscillation of the ring 214 on the eccentric portion of shaft 60. This slight tilting motion of the pad 206 is accommodated by the lower gripping pad 400 which, though rigid, tilts with
 45 upper pad 206 on the resilient support pad 402. In this manner, the upper and lower gripper pads 206 and 400 remain substantially parallel at all times during the welding sequence with the overlapping strap segments U and L pressed generally uniformly
 50 between them.

As the upper gripper pad 206 is lowered against the upper overlapping strap segment U, the bottom surface of the upper overlapping strap segment U is forced against the saw teeth 414 of the saw blade
 55 410. The reciprocating motion of the upper overlapping strap segment U relative to the saw blade 410 causes the trailing portion T (Figure 1) of the strap to be severed from the strap loop S before the overlapping strap segments U and L are joined by the
 60 friction fusion weld.

The motor 40 is rotated in the second direction to effect the friction fusion weld for a predetermined period of time, as governed by the weld sequence timer in the control system, following which the
 65 motor rotation is terminated.

The tool 20 is next removed from the tensioned and sealed strap loop by pressing downwardly on the operating lever 186 so that the operating lever cam 188 contacts the roller 160 and pivots the
 70 tension arm 130 to move the anvil 146 away from the tension wheel 126. This permits the tool to be moved laterally away from the overlapping strap segments U and L.

The downward movement of lever 186 and of the
 75 operating lever cam 188 also causes the upper end of the guide channel 454 to engage the upper end 455 of the reset link 450 (Figure 3) and to move the reset link 450 downwardly as illustrated by arrow 466 in Figure 5. This causes the rocker arm 306 to
 80 pivot from the unlatched position illustrated in Figure 7 to the latched position illustrated in Figure 5 whereat the release pawl 336, urged by the torsion spring 344, engages the leg 340 of the rocker arm and whereat the plunger 380 in the release pawl 336
 85 enters one of the grooves 372 or 374 in the release ring 350. If the entry into the grooves 372 or 374 is blocked by one of the lugs 376 or 378, the plunger 380 is forced upwardly against the compression spring 386 in bore 382 of the release pawl 336.

The tool 20 is now reset and when the downward force on the operating lever 186 is removed, the entire operating lever assembly 184 is biased upwardly by the torsion spring 184 to the position illustrated in Figure 1. In this position, the upper
 95 portion 455 of the reset link 450 rests near the bottom of the guide channel 454 and the tension arm 130 is biased by its torsion spring 166 so that anvil 146 is forced against the tension wheel 126. Downward movement of the operating lever 186 will cause
 100 the anvil 146 to move away from the tension 126 to again allow the tool to be loaded with overlapping strap segments U and L to begin another strapping sequence.

105 *Alternative saw blade embodiment*

A second embodiment of the saw blade used in the tool 20 will next be described with reference to Figures 12-15. All of the components of the tool 20 remain the same as in Figures 1-11 except for the
 110 saw blade structure and supporting elements as will be explained in detail hereinafter. Consequently, all of the elements, except for the elements relating to the saw blade and support elements, are illustrated in Figures 12-15 as being identical to the elements of the tool 20 illustrated in Figures 1-11 and those elements retain the same reference numerals.

The alternate saw blade is designated generally in Figures 12-15 by reference numeral 410a. As best illustrated in Figure 14, the saw blade 410a is
 120 mounted on pin 412 in the same manner as the first embodiment of the saw blade 410 described in detail above. The saw blade 410a is permitted to slide along the pin 412 parallel to the shaft 60 forwardly or rearwardly relative to the upper and lower gripping pads 206 and 400, respectively. The saw blade 410a is also adapted to pivot about the pin 412 between a lowered, strap-contacting position illustrated in Figure 15 and a raised, strap loading and tensioning position illustrated in Figure 14.

130 The saw blade 410a has a plurality of downwardly

projecting saw teeth 414a which are adapted to contact the upper surface of the upper overlapping strap segment U and which are adapted to cut through that upper strap segment U in a manner to be described in more detail hereinafter.

As best illustrated in Figures 12, 14, and 15, a helical compression spring 700 is disposed in a cylindrical bore 710 of a downwardly depending portion 720 of the tool side cover. A portion of the spring 700 projects from the bore 710 with the distal end of the projecting spring portion bearing upon, but not connected to, the top horizontal surface of the saw blade 410a. The spring thus exerts a continuous downward bias force against the saw blade 410a.

As illustrated best in Figure 15, with the saw blade 410a downwardly biased, the teeth 414a are in contact with the upper surface of the upper overlapping strap segment U. Movement of the upper strap segment U, in directions of the double headed arrow 226 parallel to the length of the saw blade during the friction fusion welding sequence (by means of the oscillating upper gripper pad 206), will cause the upper strap segment U to be severed.

As best illustrated in Figures 12 and 13, the forward portion of the saw blade 410a carries a pin 730. The pin 730 is preferably a spring roll pin received within a cylindrical bore 740 in the saw blade 410a. The spring roll pin 730 projects forwardly over the top of the upper gripper pad 206 and is adapted to be engaged by the top surface of the upper gripper pad 206 when the upper gripper pad 206 is raised upwardly away from the overlapping strap segments U and L. Raising of the upper gripper pad 206 will thus lift the saw blade 410a away from the overlapping strap segments U and L and will hold the saw blade 410a in the raised position until the upper gripper pad 206 is again lowered into contact with the upper strap segment U.

The spring roll pin 730 of the saw blade 410a is not connected to the upper gripper pad 206. Thus, when the upper gripper pad 206 is lowered into engagement with the upper strap segment U, the saw blade 410a is not pulled downwardly by the upper gripper pad 206. Rather, the blade 410a is urged to fall against the upper strap segment U under the influence of gravity and by the small downward force applied to the saw blade 410a by the compression spring 700. This causes the saw blade to contact and quickly cut the upper strap segment U when the upper strap segment U is reciprocated against the overlying, lowered blade by the fully lowered upper gripper pad 206.

By appropriate design, such as by taking into account the spring constant of the spring 700 and the length of the spring, the downward bias force on the saw blade 410a can be made relatively constant and of sufficient magnitude to provide an effective sawing action without causing a deleterious impingement of the saw blade upon the lower strap segment L after the upper strap segment U has been severed. It is to be remembered that the lower strap segment L is substantially immobile during the friction fusion welding process. Further, since the saw blade 410a does not oscillate, there can be no

sawing or severing of the lower strap segment L by the saw blade 410a after the upper strap segment U is cut through by the saw blade.

The position of the spring roll pin 730 in the vertical direction relative to the saw blade teeth 414a is preferably chosen so that the saw blade teeth 414a contact the upper surface of the upper strap segment U before the upper gripper pad 206 contacts the upper surface of the upper strap segment U. Thus, the saw blade is already engaged with the upper strap segment when the upper gripper pad 206 finally contacts and reciprocates the upper strap segment U.

In the preferred design, it has been found that the upper strap segment U is severed by the time the upper strap segment U has been reciprocated for about 75 percent of the total friction fusion welding period. That is, after the upper strap segment U has been severed, the upper gripper pad 206 continues to oscillate and move the severed end portion of the upper strap segment U against the lower strap segment L for an additional period of time to complete the weld. That additional weld completion time is equivalent to 25 percent of the total friction fusion welding time that the upper and lower strap segments U and L, respectively, are oscillated in contact.

It has been found that the above-described saw blade design provides a number of advantages. One advantage is a savings in operator labor when used with many types of plastic strap. Specifically, when the trailing portion of the upper strap segment U is severed, it tends to remain lightly stuck to the saw blade and/or to the loop portion of the upper strap segment with pieces of melted thermoplastic material from the adjacent friction fusion weld. The severed trailing portion of the upper strap segment U will thus remain with the tool 20 rather than fall out of the tool or be pulled out by the pre-stressed coil of strap behind the tool. Then, the operator can grab the "sticking", severed, trailing portion of the strap after the weld has been completed and, with just a small amount of force, can pull it out of the tool and away from the fused joint. The operator is then able to thread the trailing portion of the strap, which he has just removed and has in his hand, around another package and back into the tool 20. Were it not for the severed trailing portion of the strap sticking in the tool with the melted plastic, the severed strap would fall out of the tool and the operator would have to bend down and pick up the strap in preparation for encircling another package with the strap.

CLAIMS

1. A tool for constricting and closing a loop of thermoplastics strap that encircles an article and has overlapping strap segments, the tool comprising means for constricting the loop; reversible motor for rotating initially in a first direction and then in a second, opposite direction; a drive shaft driven by the motor sequentially in the first and second directions of rotation for engaging and operating the constricting means to constrict the strap loop only



projecting saw teeth 414a which are adapted to contact the upper surface of the upper overlapping strap segment U and which are adapted to cut through that upper strap segment U in a manner to be described in more detail hereinafter.

As best illustrated in Figures 12, 14, and 15, a helical compression spring 700 is disposed in a cylindrical bore 710 of a downwardly depending portion 720 of the tool side cover. A portion of the spring 700 projects from the bore 710 with the distal end of the projecting spring portion bearing upon, but not connected to, the top horizontal surface of the saw blade 410a. The spring thus exerts a continuous downward bias force against the saw blade 410a.

As illustrated best in Figure 15, with the saw blade 410a downwardly biased, the teeth 414a are in contact with the upper surface of the upper overlapping strap segment U. Movement of the upper strap segment U, in directions of the double headed arrow 226 parallel to the length of the saw blade during the friction fusion welding sequence (by means of the oscillating upper gripper pad 206), will cause the upper strap segment U to be severed.

As best illustrated in Figures 12 and 13, the forward portion of the saw blade 410a carries a pin 730. The pin 730 is preferably a spring roll pin received within a cylindrical bore 740 in the saw blade 410a. The spring roll pin 730 projects forwardly over the top of the upper gripper pad 206 and is adapted to be engaged by the top surface of the upper gripper pad 206 when the upper gripper pad 206 is raised upwardly away from the overlapping strap segments U and L. Raising of the upper gripper pad 206 will thus lift the saw blade 410a away from the overlapping strap segments U and L and will hold the saw blade 410a in the raised position until the upper gripper pad 206 is again lowered into contact with the upper strap segment U.

The spring roll pin 730 of the saw blade 410a is not connected to the upper gripper pad 206. Thus, when the upper gripper pad 206 is lowered into engagement with the upper strap segment U, the saw blade 410a is not pulled downwardly by the upper gripper pad 206. Rather, the blade 410a is urged to fall against the upper strap segment U under the influence of gravity and by the small downward force applied to the saw blade 410a by the compression spring 700. This causes the saw blade to contact and quickly cut the upper strap segment U when the upper strap segment U is reciprocated against the overlying, lowered blade by the fully lowered upper gripper pad 206.

By appropriate design, such as by taking into account the spring constant of the spring 700 and the length of the spring, the downward bias force on the saw blade 410a can be made relatively constant and of sufficient magnitude to provide an effective sawing action without causing a deleterious impingement of the saw blade upon the lower strap segment L after the upper strap segment U has been severed. It is to be remembered that the lower strap segment L is substantially immobile during the friction fusion welding process. Further, since the saw blade 410a does not oscillate, there can be no

sawing or severing of the lower strap segment L by the saw blade 410a after the upper strap segment U is cut through by the saw blade.

The position of the spring roll pin 730 in the vertical direction relative to the saw blade teeth 414a is preferably chosen so that the saw blade teeth 414a contact the upper surface of the upper strap segment U before the upper gripper pad 206 contacts the upper surface of the upper strap segment U. Thus, the saw blade is already engaged with the upper strap segment when the upper gripper pad 206 finally contacts and reciprocates the upper strap segment U.

In the preferred design, it has been found that the upper strap segment U is severed by the time the upper strap segment U has been reciprocated for about 75 percent of the total friction fusion welding period. That is, after the upper strap segment U has been severed, the upper gripper pad 206 continues to oscillate and move the severed end portion of the upper strap segment U against the lower strap segment L for an additional period of time to complete the weld. That additional weld completion time is equivalent to 25 percent of the total friction fusion welding time that the upper and lower strap segments U and L, respectively, are oscillated in contact.

It has been found that the above-described saw blade design provides a number of advantages. One advantage is a savings in operator labor when used with many types of plastic strap. Specifically, when the trailing portion of the upper strap segment U is severed, it tends to remain lightly stuck to the saw blade and/or to the loop portion of the upper strap segment with pieces of melted thermoplastic material from the adjacent friction fusion weld. The severed trailing portion of the upper strap segment U will thus remain with the tool 20 rather than fall out of the tool or be pulled out by the pre-stressed coil of strap behind the tool. Then, the operator can grab the "sticking", severed, trailing portion of the strap after the weld has been completed and, with just a small amount of force, can pull it out of the tool and away from the fused joint. The operator is then able to thread the trailing portion of the strap, which he has just removed and has in his hand, around another package and back into the tool 20. Were it not for the severed trailing portion of the strap sticking in the tool with the melted plastic, the severed strap would fall out of the tool and the operator would have to bend down and pick up the strap in preparation for encircling another package with the strap.

CLAIMS

1. A tool for constricting and closing a loop of thermoplastics strap that encircles an article and has overlapping strap segments, the tool comprising means for constricting the loop; reversible motor for rotating initially in a first direction and then in a second, opposite direction; a drive shaft driven by the motor sequentially in the first and second directions of rotation for engaging and operating the constricting means to constrict the strap loop only



when the drive shaft is rotated in the first direction; sensing and control means for sensing a predetermined level of tension in the constricted strap loop and for reversing the rotation of the motor to change the rotation of the drive shaft from the first direction of rotation to the second direction of rotation; and means responsive to rotation of the drive shaft in the second direction for pressing the overlapping strap segments together after the strap loop has been constricted to the predetermined tension level and for moving one of the overlapping strap segments relative to the other strap segment to effect a friction fusion weld of the overlapping segments.

2. A tool as claimed in Claim 1 in which the drive shaft includes a first shaft connected to be driven by the motor, in which the constricting means includes at least a second shaft, and in which the drive shaft further includes a clutch drivably connecting the first shaft with the second shaft for rotating the second shaft in the first direction to constrict the loop and adapted to disengage the second shaft from the first shaft when the first shaft is rotated in the second direction.

3. A tool as claimed in Claim 1 or Claim 2 in which the tool includes a saw blade pivotally mounted on the frame and having downwardly projecting saw teeth, the saw blade being pivotable between a lowered position contacting the upper surface of the one overlapping strap segment and an elevated position spaced from the upper surface of the one overlapping strap segment, the saw blade including means engageable by the pressing means operable to move the saw blade to the elevated position from the lowered position; and in which the tool further includes means for biasing the saw blade against the upper surface of the one overlapping strap segment when the pressing means is effecting the friction fusion weld thereby causing the saw blade to cut through the one overlapping strap segment before the straps are welded together thus severing the trailing portion of the strap loop.

4. Tool for tensioning and sealing a loop of thermoplastics strap that encircles an article and has first and second overlapping strap segments, the tool comprising a frame; a first shaft mounted for rotation about its longitudinal axis relative to the frame, the first shaft defining a bore having a longitudinal axis concentric with the longitudinal axis of rotation of the first shaft; an electrically operated, reversible motor carried by the frame for rotating the first shaft sequentially in a first direction and then in a second, opposite direction; a second shaft having one end in the bore of the first shaft and mounted for rotation about its longitudinal axis relative to the frame; a tensioning means mounted on the frame for initially gripping the first overlapping segment of the strap and moving the strap to tension the loop; transmission means drivably connecting the second shaft with the tensioning means; at least one one-way clutch within the bore of the first shaft for engaging the first and second shafts to permit rotation of the second shaft with the first shaft in the first direction to tension the strap loop and to permit the first shaft to rotate in the second direction without effecting a rotation of the second

shaft; means for sensing a predetermined level of tension in the strap loop; control means responsive to the loop tension sensing means for reversing the rotation of the motor from the first direction of rotation to the second direction of rotation when the predetermined loop tension level is sensed by the tension sensing means; means responsive to the rotation of the first shaft in the second direction for pressing the first and second overlapping strap segments together after the strap loop has been tensioned to the predetermined level; and oscillating drive means on the first shaft for oscillating the strap pressing means to move the first overlapping strap segment generally transversely of the strap length relative to the second overlapping strap segment to effect a friction fusion weld of the overlapping segments.

5. A tool as claimed in Claim 4 in which the pressing means includes: a pressing member adapted to be oscillated by the oscillating means; a rocker arm pivotally mounted on the frame; a link pivotally connected at one end to one end of the rocker arm and pivotally connected at the other end to the pressing member; a rocker arm spring for urging the rocker arm to pivot relative to the frame to force the pressing member against the first overlapping strap segment; a release pawl pivotally mounted on the frame having a latch for engaging the second end of the rocker arm; a release pawl spring for urging the release pawl against the second end of the rocker arm to engage the latch; a release ring mounted about the first shaft and adapted to engage the release pawl; and a second clutch drivably connecting the first shaft with the release ring for rotating the release ring with the first shaft in the second direction and adapted to disengage the release ring from the first shaft when the first shaft is rotated in the first direction.

6. A tool as claimed in Claim 5 in which rotation of the first shaft in the second direction causes the release ring to rotate in the second direction to force the release pawl to pivot away from the second end of the rocker arm so as to release the second end of the rocker arm from the release pawl latch so that the rocker arm is urged by the rocker arm spring to force the pressing member against the first overlapping strap segment.

7. A tool as claimed in any of Claims 4 to 6 in which the release ring has a peripheral groove and at least one wall across the groove for engaging the release pawl.

8. A tool as claimed in any of Claim 7 which the release pawl has a bore, a plunger slidably mounted within the bore, and a compression spring within the bore adapted to urge the plunger into the groove in the release ring; and in which the release pawl has a cam surface adapted to be engaged by the second end of the rocker arm when that end is disengaged from the latch whereby the release pawl is held with the plunger away from the release ring wall.

9. A tool as claimed in Claim 8 further including a reset link secured to the rocker arm adapted to be forced in one direction to pivot the rocker arm against the force of the rocker arm spring to bring the second end of the rocker arm into engagement



with the latch whereby, when the said release ring is rotated in the second direction, the release ring wall forces the plunger and the release pawl away from the release ring thereby pivoting the release pawl to
5 disengage the latch from the second end of the rocker arm so that the rocker arm is urged by the rocker arm spring to move the reset link to urge the pressing means into contact with the first overlapping strap segment and whereby, when the reset link
10 is forced to relatch the rocker arm with the release pawl, the compression spring permits the plunger to be moved further into the bore if the release ring should contact the plunger.

10. A tool as claimed in any of Claims 4 to 9 in
15 which the tensioning means includes a tensioning wheel adapted to grip the strap; a tensioning arm pivotally mounted on the frame, the tensioning arm having a tensioning foot adjacent the tensioning wheel; and a tensioning arm spring urging the
20 tensioning arm to pivot relative to the frame to urge the tensioning foot towards the tensioning wheel to press the first and second overlapping strap segments between the tensioning wheel and tensioning foot.

25 11. A tool as claimed in any of Claims 4 to 10 in which the tension sensing means includes an abutment member adjacent the tensioning arm; a switch on the tensioning arm responsive to movement of the tensioning arm against the abutment member
30 for actuating the control means; and a spring plate cantilevered over the switch to absorb impact energy when the tensioning arm is suddenly moved against the switch by the abutment member.

12. A tool as claimed in any of Claim 4 to 11
35 which the oscillating drive means includes an eccentric portion on the first shaft having a generally cylindrical exterior drive surface orientated about a longitudinal axis parallel to, but displaced from, the first shaft longitudinal axis; in which the oscillating
40 means further includes a driven ring mounted about the eccentric portion for revolution about the first shaft longitudinal axis with the eccentric portion during rotation of the first shaft in either of the first and second directions of rotation, the driven ring
45 having a generally cylindrical inner driven surface disposed on the generally cylindrical exterior drive surface of the eccentric portion to permit rotation of the eccentric portion within and relative to the driven ring; and in which the pressing means includes a
50 pressing member mounted on the driven ring for contacting the first overlapping strap segment whereby rotation of the first shaft oscillates the pressing member.

13. A tool for constricting and closing a loop of
55 thermoplastics strap that encircles an article, constructed and arranged substantially as herein specifically described with reference to and as shown in Figures 1 to 11 or as shown in Figures 1 to 11 with the modification shown in Figures 12 to 15 of the
60 accompanying drawings.