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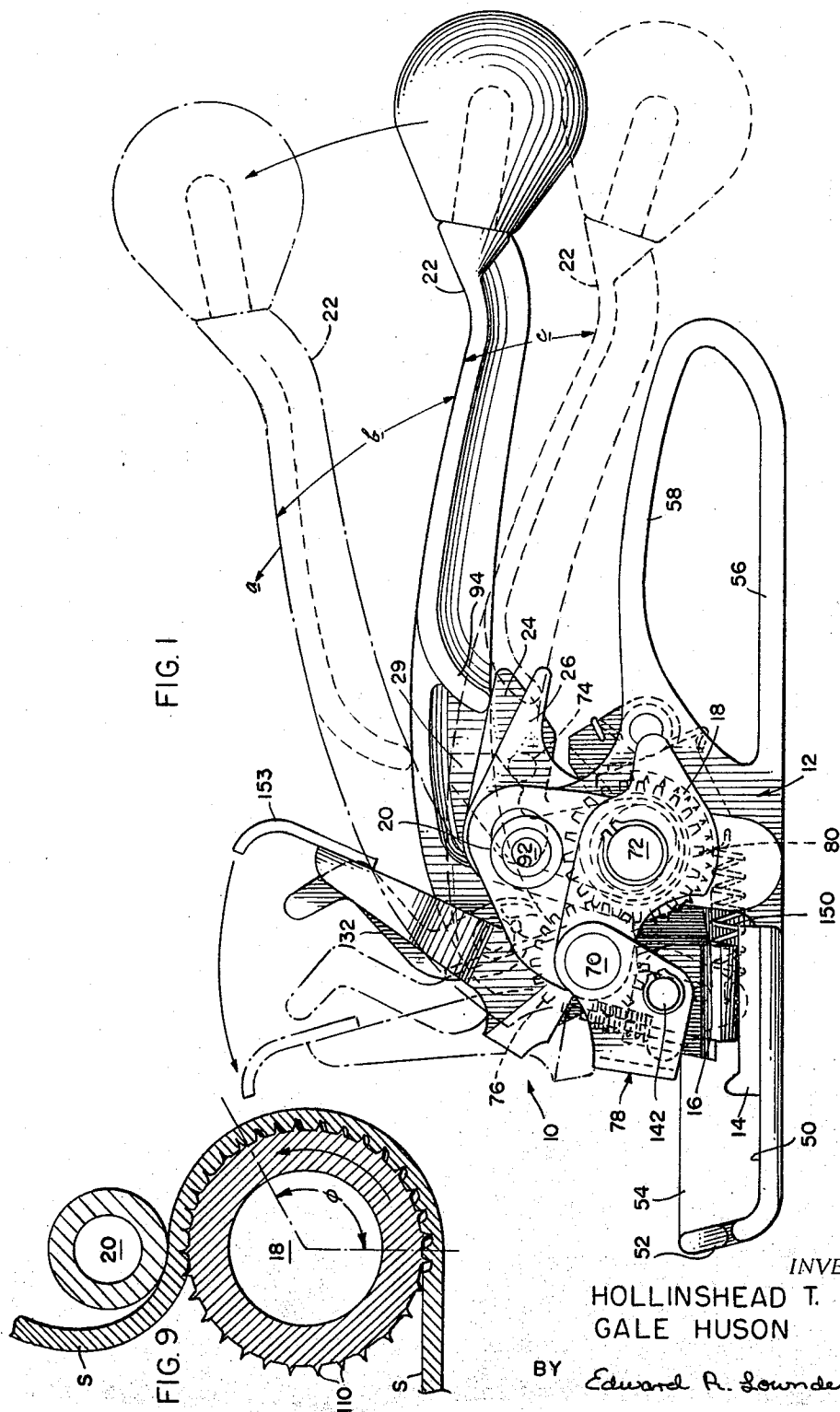
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3,265,355

STRAP TENSIONING METHOD AND MECHANISM FOR STRAPPING TOOLS

Filed April 12, 1965

3 Sheets-Sheet 1



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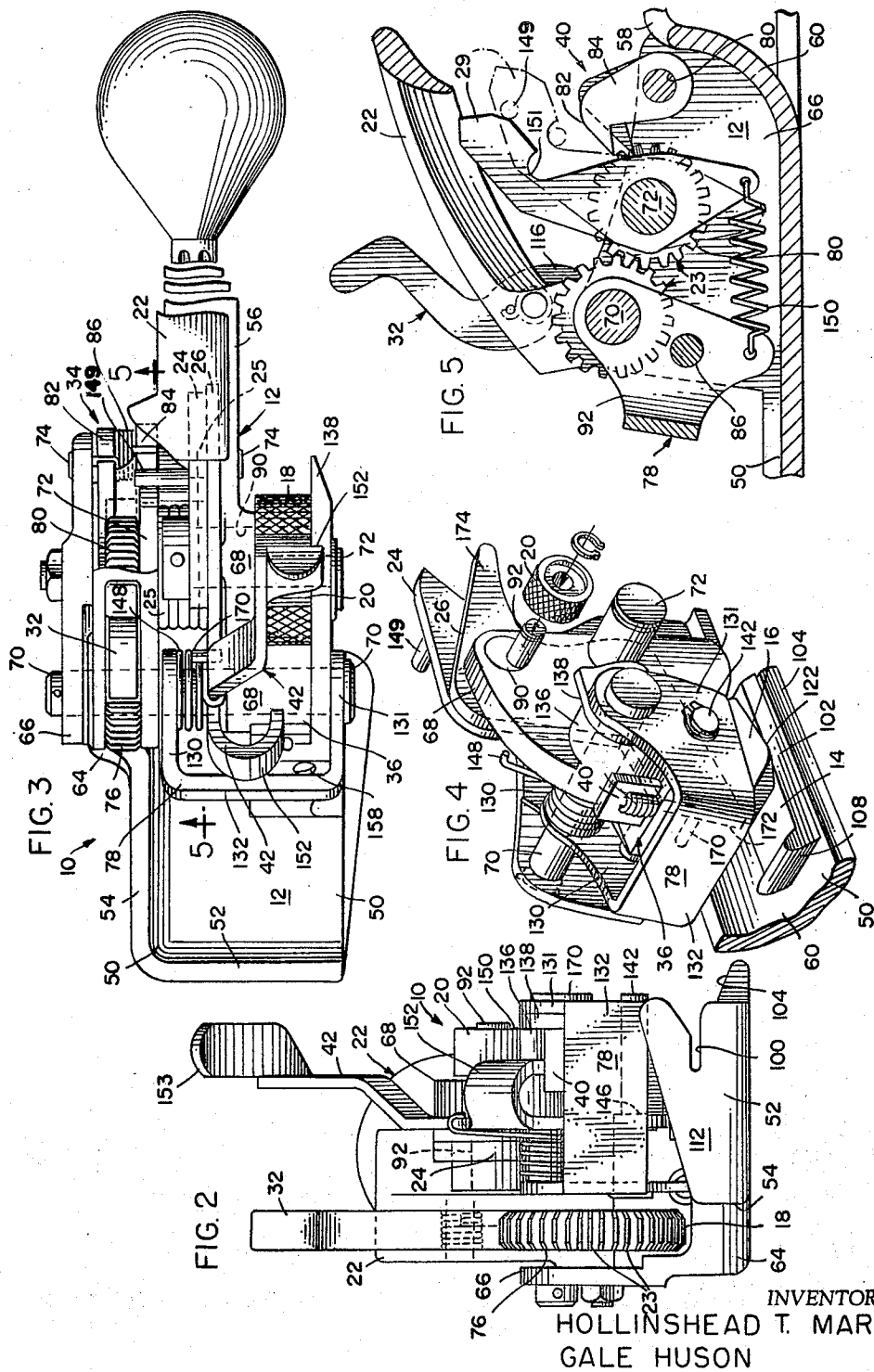
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BY

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3,265,355 STRAP TENSIONING METHOD AND MECHANISM FOR STRAPPING TOOLS

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The present invention relates to strapping tools and has particular reference to a portable hand operated strapping tool which is designed to operate upon plastic strapping for tensioning or stretching such strapping about an object preparatory to sealing and severing the overlapping end portions of the strapping to produce a tensioned strap around the object. More specifically, the invention is concerned with a novel method by means of which strap tensioning operations are effected, as well as with a mechanism by means of which the method may effectively be carried out. The invention, although designed primarily for use in connection with plastic strapping, is not necessarily limited to such use and mechanisms constructed according to the invention may, if desired, with or without modification as required, be employed for the tensioning of soft steel or other ductile metal strapping. Irrespective however of the particular use to which the present invention may be put, the essential features thereof are at all times preserved.

Strapping tools of the type under consideration are predicated upon the provision of a loop of strapping which encircles the article undergoing binding and which has a free end portion and an overlapping feed end portion. The free end portion is fixedly clamped against longitudinal shifting movement while pulling force is applied to the feed end portion to tension the strapping about the object. When the required degree of tension is attained, a seal is crimped about the overlapping portions and the feed end portion is then severed from the strapping, thus leaving a tensioned strap in position about the object.

Generally speaking, three different methods of applying pulling force to the feed end portion of the strapping are currently employed. According to one widely used method, the feed end portion of the strapping is caused to slide upon the free end portion which it directly overlies by means of a feed wheel which has a peripheral friction surface that bears tangentially and tractionally against the feed end portion. Thus, when the feed wheel is rotated in a tensioning direction, pulling force is applied to the free end portion. Another commonly employed method is predicated upon the use of a windlass upon which the feed end portion of the strapping is wound so that, upon rotation to the windlass in a tensioning direction, pulling force is applied to the feed end portion. A third method involves the use of a reciprocable gripper assembly which exerts a binding action upon the feed end portion of the strapping when moving in a tensioning direction and which releases the feed end portion when performing its return stroke, suitable holding means being provided to retain the accumulated tensioning increments. Due to space limitations, this latter method is impractical for small portable hand tools and finds more general application in connection with large industrial strapping machines where steel strapping is concerned.

Both the traction feed wheel method and the windlass method mentioned above are possessed of limitations peculiar to themselves and which are particularly prevalent in connection with the handling of plastic or soft steel strapping. For example, with the feed wheel method of strap tensioning, only a thin line or area of contact between the feed wheel and the strapping is attained during tensioning and therefore the pressure involved is critical and must be maintained below a predetermined

maximum to avoid strap deformation and consequent strap weakening. Additionally, due to the eccentric mounting usually employed for moving the feed wheel into and out of strap-engaging position, and due to the fact that eccentric movement of the feed wheel out of strap-engaging position at the end of the tensioning operation invariably involves a component of shifting movement in a direction tending to further tension the already tensioned strapping, difficulty is encountered in releasing the strapping tool from the strapping after the seal has been applied.

Where the windlass method of strap tensioning is concerned, difficulties or limitations of a different variety arise. Exemplary of these limitations is the necessity for pre-shearing of the strapping to provide a free end for insertion into the windlass slot. Thus, after the final strap shearing operation in the vicinity of the seal, the length of strapping wound upon the windlass and extending rearwardly to the severed end of the strapping represents strap waste, to say nothing about the skill which is required to load and unload the windlass.

Other limitations, too numerous to mention, are attendant upon both the traction feed wheel and the windlass methods of strap tensioning and are well known to strapping tool manufacturers who have devised various ways of minimizing their effect, but not without adding appreciably to the cost of the strapping tools involved.

The present invention provides a novel method of strap tensioning wherein the principal problems of strap release, strap shearing or deformation, and many of the other problems or limitations associated with the traction feed wheel and with the windlass method of strap tensioning do not arise and which, moreover, is possessed of several advantages not present in connection with either of these known methods. The present method may be referred to as a "wrap-around" method inasmuch as it involves the partial wrapping of the feed end portion of the strapping around a strap-pulling tensioning or feed wheel having a specially designed peripheral friction surface thereon and the attainment of good frictional characteristics between the tensioning wheel and the curved portion of the strapping which is thus wrapped therearound.

Briefly, in carrying out the present method, after the free end portion of the plastic strapping has been fixedly anchored in position on the strapping tool anvil or clutch plate, it is passed around the article to be bound and the feed end portion is brought into overlapping relationship with respect to the anchored free end portion in the usual manner. The unsevered feed end portion is then caused to pass partially around a hardened steel feed wheel the peripheral surface of which is provided with a multiplicity of relatively small closely spaced pointed protuberances the radial extent or height of which is appreciably less than the thickness of the plastic strapping but which, nevertheless, are capable of strap-penetration.

The feed wheel is provided for the purpose of frictionally gripping the arcuate portion of the strapping which is thus wrapped around it but, due to the elasticity of the strapping and its tendency to maintain straight line or planar direction throughout small increments of length, it is necessary, initially at least, to maintain a reentrant bend in the strapping so that when the feed wheel is rotated in a tensioning direction it will "seize" the strapping and feed the same. Toward this end, a combined guide and hold-down roller is provided which engages the strapping and yieldingly presses the same against the feed wheel at a point which is circumferentially removed from the point of tangential strap entry. Preferably, this hold-down roller is positioned at a region which is 180° removed from the tangential point of strap entry upon the feed wheel. The hold-down roller is movable bodily toward and away from the feed wheel for strap-installation and strap-removal purposes and, when it is in operative

engagement with the strapping it is spring pressed there-against so as to apply pressure to the strapping at the region where the latter passes between the feed wheel and hold-down roller.

After the hold-down roller has thus initially been moved into clamping engagement with the strapping to bind the same against the feed wheel, the protuberances on the feed wheel in the immediate vicinity of the tangential region involved are caused to penetrate the strapping so that, in this region at least, there will be some strap penetration and good frictional binding of the strapping to the feed wheel. Then, as the feed wheel is rotated in a tensioning direction, the remainder of the strapping which loosely but directly opposes the circumference of the feed wheel is literally pulled into firm frictional engagement with the feed wheel so that strap penetration by the protuberances takes place throughout approximately 180° on the circumference of the feed wheel.

During continued rotation of the feed wheel in a tensioning direction, and due to the elasticity of the strapping, a graduated frictional engagement between the feed wheel and the strapping will take place, the protuberances which are closer to the point of tangential strap entry exerting a greater "pull" upon the strapping than those which are farther removed. This graduated effect tapers off to nothingness before the 180° extent of circumferential contact between the strapping and feed wheel has been reached, the load on the feed wheel being assimilated by only those protuberances which are disposed within a range of about 120° from the tangential point of strap entry on the feed wheel. Actually, after an initial strap installation and an initial increment of feed wheel rotation in a tensioning direction, the hold-down roller could be removed from strap engagement and the pulling effect of the protuberances within the 120° range relied upon solely to maintain driving friction between the feed wheel and strapping.

We are aware that the use of strap or belt tensioning rollers in connection with friction drive pulleys is well known, such rollers being widely used in the web tensioning art as for example in newspaper presses and the like, as well as in connection with belt-driven machinery and friction clutches. In such instances the drive involved is a friction drive where the load is distributed by an intermediate web-tensioning roller between a drive roller and a remote driven roller. In the present instance, the so-called hold-down roller has no tensioning effect, it serving initially and momentarily as a pressure roller to attain limited strap-penetration by a few strap-driving protuberances, and thereafter serving as a guide roller to maintain a reentrant bend in the strapping and prevent pulling away from the feed wheel during interruption of the feed wheel drive, as for example when an intermittent drive is employed.

The provision of a novel strap tensioning method such as has briefly been outlined above constitutes the principal objects of the present invention. Various mechanisms may be employed in practicing the method, depending upon the design of the particular strapping tool involved and the desired over-all functions to be attained. The method has been developed in connection with a particular and novel strapping tool which is of the hand tool variety and wherein the feed wheel is intermittently actuated by a ratchet and pawl mechanism and wherein the hold-down roller is moved into and out of cooperation with the feed wheel by an eccentric orbiting of the former. Specifically, the strapping tool involved is of the general type shown and described in a copending United States application of Gale Huson, Serial No. 430,646, filed February 5, 1965, and entitled, "Gripper Mechanism for Strapping Tools." The wrap-around feature of the present invention constitutes an incidental disclosure of the Huson application, the invention involved in such application being directed to a certain gripper foot release mechanism disclosed therein. The present application discloses the gripper foot release mechanism

of the Huson application and it provides for a novel control mechanism whereby the gripper foot release mechanism and the movements of the hold-down roller employed in connection with the present strap tensioning method and mechanism may conveniently be actuated under the control of a single manipulating lever, the lever serving when operated in a first range of movement to effect strap tensioning operations, when operated in a second range to move the hold-down roller to an inoperative position of strap release and cause the roller to be latched in such inoperative position, and when operated in a third range to effect operation of the gripper release mechanism, all in a manner that will be made clear presently. The provision of such a joint lever control mechanism constitutes another object of the present invention.

Other objects and advantages of the invention, not at this time enumerated, will readily suggest themselves as the nature of the invention is better understood.

In the accompanying three sheets of drawings forming a part of this specification, one illustrative embodiment of the invention has been shown.

In these drawings:

FIG. 1 is a side elevational view of a strapping tool constructed according to the principles of the present invention, the parts being shown in the free or normal positions thereof;

FIG. 2 is an end elevational view of the strapping tool;

FIG. 3 is a top plan view of the strapping tool;

FIG. 4 is an enlarged fragmentary perspective view of a sub-assembly of parts including a combined gripper foot and cutter unit and a hold-down roller employed in connection with the invention, together with the mounting means therefor;

FIG. 5 is a sectional view taken substantially along the line 5—5 of FIG. 3 and in the direction of the arrows;

FIGS. 6, 7 and 8 are similar fragmentary sectional views, schematic in their representation, taken longitudinally through the strapping tool in the vicinity of the hold-down roller and gripper foot and illustrating progressively the cam-controlled action of these two instrumentalities during tool operation; and

FIG. 9 is a schematic sectional view taken transversely through the feed wheel and its associated hold-down roller and illustrating the distribution of tension in the strapping during the tensioning operation.

Referring now to the drawings in detail and in particular to FIGS. 1 to 3 inclusive, a strapping tool embodying the strap-feeding mechanism of the present invention has been designated in its entirety at 10. The tool 10 is a hand operated tool and it is merely exemplary of one form of strapping tool which the present strap feeding mechanism may be applied. It will be distinctly understood however that the strap feeding mechanism of the present invention may, if desired, with or without modification as required, be applied to other forms of strapping tools, whether the same be hand or power operated. Irrespective of the particular form of strapping tool to which the strap feeding mechanism is applied, the essential features of the invention are at all times preserved.

Briefly, the strapping tool 10 involves in its general organization a main frame or chassis 12 upon which all of the operating instrumentalities of the tool are operatively assembled. These instrumentalities include a fixed gripper anvil 14 (see also FIG. 4) and a cooperating gripper foot 16, a strap-tensioning wheel 18, a cooperating hold-down roller 20, and an operating lever 22 having a first range of swinging movement *a* (see also FIG. 6), a second range of swinging movement *b*, and a third range of swinging movement *c*. Within the first range *a*, movement of the operating lever 22 serves to actuate the strap-tensioning wheel 18 by means of a gear train 23 (FIGS. 2 and 5). Within the second range *b*, the lever 22 serves to actuate the hold-down roller 20. Within the third range of movement *c*, the lever 22 serves to actuate certain gripper release mechanism which constitutes the subject matter of the abovementioned application of Gale

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Huson, while at the same time the hold-down roller is latched in an inoperative position, the particular latching mechanism employed for this purpose constituting a feature of the present invention.

In applying the tool 10 to the strapping S, the operating lever 22 is moved from the range *a*, through the range *b*, and into the range *c*. In moving through the range *b*, the lever actuates a cam 24 (FIGS. 6, 7 and 8) which raises the hold-down roller 20 out of cooperating engagement with the strap-tensioning wheel 18. Within the range *c* the lever 22 is effective by means of a kickout cam 26 to elevate the gripper foot 16 from the gripper anvil 14.

The operating lever 22, in passing to the range *c*, will previously have been moved through the range *b* wherein certain latching mechanism including a latch proper 29 (FIGS. 5 to 8 inclusive) became effective to latch the hold-down roller 20 in an inoperative position removed from the tensioning wheel 18. With the hold-down roller 20 removed from the strap-tensioning wheel 18 and the gripper foot 16 elevated from the anvil 14; the free end region 28 of the strapping S is then inserted sidewise within the space thus created between the gripper foot 16 and anvil 14 as shown in FIG. 6; the strapping S is passed around the object O and brought into overlapping relationship with the free end region 28; the feed portion 30 of the strapping is then passed over the gripper foot 16 as shown in dotted lines, is partially wrapped around the tensioning wheel 18 and is introduced sidewise between the wheel 18 and hold-down roller 20, the strapping S extending from the hold-down roller 20 to a suitable source of the strapping (not shown) positioned either above or below the level of the tool 10.

The operating lever 22 is then moved back into the range *a* and, upon leaving the range *c* the gripper foot 16 is lowered into gripping contact with the free end region 28 of the strapping S, thus clamping this region hard against the anvil 14. In moving through the range *b*, the latching mechanism is released and the hold-down roller 20 is moved into cooperating clamping relationship with the tensioning wheel 18 to clamp the feed portion 30 of the strapping thereagainst. Then, in the range *a*, the operating lever 22 is rocked back and forth, thus actuating certain ratchet and pawl mechanism including an operating pawl 32 (FIGS. 2 and 3) carried by the handle 22 and a dual holding pawl assembly 34, to advance the tensioning wheel 18 in a counterclockwise direction as indicated by the arrow in FIG. 6 in step-by-step fashion and thus pull the feed portion 30 of the strapping S to the right and tension the same about the object O.

The gripper foot 16 is formed as an integral portion of a gripper block 36 and the latter has associated therewith a cutter assembly including a cutter blade proper 40, operable under the control of a lever 42 (FIGS. 1 and 2) to effect shearing of the excess portion of the strapping after the strapping has been tensioned about the object O. Prior to manipulation of the lever 42 for shearing purposes, a conventional seal 44 (FIG. 6) is applied to the overlapping portions of the strap forwardly of the gripper anvil 14. Then, with the lever 22 remaining in the range *a*, the lever 42 is actuated to cause the cutter blade 40 to shear the upper overlapping portion of the strapping S against the forward edge of the gripper foot 16, thereby freeing the tensioned strapping from the source of strapping material and completing a circumscribed, tensioned and sealed strap 46 about the object O as indicated in full lines.

Finally, to free the strapping tool 10 from the thus strapped object O, the operating lever 22 is returned through the range *b* to the range *c* and depressed as previously indicated to effect release of the gripper foot from its clamping cooperation with the gripper anvil 14 and from the strapping S as well as to raise the hold-

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down roller 20 from the strap-tensioning wheel 18. During such manipulation of the lever 22, the kick-out cam 26 becomes effective to raise the gripper block 36, and consequently the gripper foot 16, from the strap S. The strapping tool 10 may then be slid sidewise from the tensioned strap 46.

During such return movement of the lever 22, as the same passes through the range *b* the previously mentioned latching mechanism including the latch proper 29 assumes its latched condition and maintains the hold-down roller 20 elevated from the tensioning wheel 16. The operating lever 22 may be left in its full line position as shown in FIG. 1, which corresponds to the position of FIG. 6, wherein the hold-down roller 20 is separated from the tensioning wheel 30 for reception of the strapping S between the roller and wheel during a subsequent tool-loading operation.

Considering the tool 10 in greater detail, the chassis or framework 12 is preferably in the form of a casting including a flat base portion the forward region of which provides upwardly presented shallow tray-like support 50 on which the previously mentioned gripper anvil 14 is fixedly mounted. The area immediately above this support 50 and slightly rearwardly thereof constitutes the working area of the tool. A transverse wall 52 extends along the forward edge of the support 50 and a similar wall 54 extends along one longitudinal edge of the support. An elongated narrow extension 56 (FIGS. 1 and 6) extends rearwardly from the support 50 in the general plane thereof and the rear end of this extension merges with an arched reentrant portion 58 which overlies the extension and, in turn merges with an upwardly and rearwardly inclined wall portion 60 of somewhat greater height than the height of the walls 52 and 54. The extension 56 and arched portion 58 constitute, in effect, an integral handle which may be employed for transporting the strapping tool, and the upper arched portion 58 of which constitutes a reaction member adapted to be gripped by four fingers of the hand, while the operating lever 22 is engaged by the ball portion of the thumb so that, by a squeezing action, the handle may be depressed toward the base extension 56 during final movement of the handle in the range *c* thereof to bring the same to the position wherein it is illustrated in FIG. 8 for gripper foot-releasing purposes, all in a manner that will be described subsequently.

The longitudinal wall 54 merges gradually at 64 (FIG. 3) with an upstanding vertical side member 66, the latter being offset outwardly of the wall 54. The side member 66 is opposed by a second side member 68 which is positioned rearwardly of the base support 50 and is disposed between this base support and the arched portion 68 of the handle. The two upstanding side members 66 and 68 serve to support therebetween three transverse shafts 70, 72 and 74 (see also FIGS. 5 and 6). The shaft 70 is a fixed shaft and it constitutes a pivotal support for the proximate end of the operating lever 22 and for the proximate end of the cutter-actuating lever 42. It also rotatably carries a combined idler and ratchet gear 76 associated with the previously mentioned gear train 23. The shaft 70 further serves as a pivotal support for a gripper cradle 78, the nature and function of which will be made clear presently. The shaft 72 constitutes the driving or feed shaft for the tensioning wheel 18, the latter being fixedly secured to the shaft 72 alongside the support 68 and on the side thereof remote from the support 66. The shaft 72 also carries a driving gear 80 which meshes with the idler gear 76 as best seen in FIG. 3. Additionally, the shaft 72 serves to pivotally support the latch 29. The shaft 74 serves to support thereon a pair of holding pawls 82 and 84 which constitute the dual pawl assembly 34 and which are spring pressed as at 86 against the driving gear 80 and cooperate therewith in the usual manner of such holding pawls to prevent reverse rotation of the driving gear.

Rotatably carried in the upper region of the support 68 is an eccentric rock shaft 90 (FIGS. 2, 4 and 6) having a reduced eccentric extension 92 projecting laterally from the side support 68 and overlying the projecting end of the shaft 72. The hold-down roller 20 is freely and rotatably mounted on the eccentric extension 92. The eccentric rock shaft 90 serves to rotatably support the previously mentioned kick-out cam 26 while the cam 24 is fixedly secured to this shaft and is normally maintained in the full line position in which it is shown in FIG. 6 by means of a spring 25 (FIGS. 2 and 3) which encircles the driving or feed shaft 72 and bears at its free end against the cam 26.

The operating lever 22 is formed with a laterally offset cam-engaging shoulder portion 94 which is capable of overlying both the cam 24 and the cam 26 and which moves into engagement first with the cam 24 as the operating lever 22 enters the range *b* after leaving the range *a*, and secondly with the cam 26 as the lever 22 enters the range *c* after leaving the range *b*. Thus it will be seen that during clockwise swinging movement of the lever 22 as viewed in FIGS. 1 and 6, initial engagement and depression of the cam 24 by the shoulder 94 and actuation of the cam will cause orbital movement of the eccentric extension 92 in a direction to withdraw the hold-down roller 20 from clamping cooperating with the tensioning wheel 18 for insertion of the strapping S between the roller and wheel or for release of the strapping at the end of a given strap severing operation as the case may be. Subsequent engagement and depression of the kick-out cam 26 by the shoulder portion 94 will serve to effect gripper release operations as schematically illustrated in FIGS. 6, 7 and 8.

As best seen in FIGS. 2, 6, 7 and 8, the exposed end edge of the transverse wall 62 on the base support 60 is provided with a tapered slot 100 for reception therein of the overlapping portions of the strapping S at the time of initial installation of the strapping in the tool 10. This slot 100 serves to guide the strapping and align the same with the gripper anvil 14 and tensioning wheel 18. The gripper anvil 14 is in the form of a hardened steel plate of elongated rectangular configuration and having an outside bevelled edge 102 which constitutes, in effect, an extension of a similar bevelled edge 104 (FIG. 2) formed on the front side edge of the base support 50 so that the strapping may be readily guided into the working area of the strapping tool. The gripper anvil 14 may be removably secured in position on the upper surface of the support in any suitable manner, as for example by fastening screws 106. The forward edge of the anvil 14 is formed with a raised transverse rib 108 over which the strapping S passes and on which it is supported when the same is initially projected into the working area of the tool.

The medial region of the strapping passes around approximately 180° of the circumference of the tensioning wheel 18 before it makes its reentrant bend around the hold-down roller 20. The outer surface of the tensioning wheel 18 is provided with a multiplicity of relatively small protuberances 110 (see also FIG. 9) presenting sharp points and these protuberances offer an appreciable degree of frictional drag to the relatively soft plastic strapping S, during tensioning operations after the hold-down roller 20 has been lowered into contact with the tensioning wheel. The manner in which the protuberances 110 cooperate with the plastic strapping on the tensioning wheel 16 constitutes one of the principal features of the present invention and will be described in greater detail subsequently.

Referring now to FIGS. 4 and 6, the gripper block 36 is generally of rectangular configuration and it is formed with a relatively deep slot 120 therein, thus defining the gripper foot 16 which projects outwardly a slight distance beyond the front side face of the block 34. The front edge of the gripper foot 16 is bevelled downwardly as at

122 and cooperates with the upwardly bevelled edge 102 to establish a tapered guide channel for entry of the strapping into the working area of the tool at the time that initial strap installation is effected. The underneath clamping area of the gripper foot 16 is provided with a multiplicity of relatively small pointed protuberances 124 which may be similar to the protuberances 110 on the tensioning wheel 18, these protuberances serving to enhance the frictional characteristics of the gripper foot on the plastic strapping S when the gripper foot is in its operative clamping position thereon.

The gripper cradle 78 is in the form of a swinging bracket of U-shape design and having parallel side wings 130 and 131 (FIGS. 3 and 4) and a connecting bight portion 132. The side wings project upwardly above the bight portion 132 and the upper regions thereof support therebetween the transverse supporting shaft 70. The cradle 78 is thus suspended from the shaft 70 with the side wings straddling the upstanding side member 68 of the tool framework or chassis 12. A circular boss 136 is formed on the side member 68 and, in combination with a stationary guide plate 138 which is supported on the shafts 70 and 72 serves to space the side wing 131 laterally from the side member 68 proper. The guide plate 138 extends across the front end face of the tensioning wheel 18 and extends below the level of the latter, and slightly rearwardly thereof, thus serving as an edge guide for the strapping S which is partially wrapped around the wheel.

Still referring to FIGS. 3 and 4, the side wings 130 and 131 of the gripper cradle 78 serve to support therebetween an elongated pivot pin 142 which passes through a transverse bore 144 formed substantially centrally in the gripper block 36. The gripper block 36 is thus pivotally supported within the confines of the cradle 78 below the level of the suspension shaft 70, the shaft 70 and pin 142 establishing a dual pivot arrangement for the gripper block and by means of which the latter is floatingly suspended within the working area of the strapping tool 10. The cradle 78 thus, in effect, constitutes a supporting link for the gripper block 36, the upper end of the link being pivoted to the main frame or chassis 12 and the lower end of the link serving to pivotally support the gripper block. The pivot pin 142 is formed with a shoulder 146 (FIG. 2) by means of which the gripper block 36 is maintained spaced from the side wing 130 of the cradle 78, thus affording a clearance space between the side wing 130 and gripper block 36. A coil spring 148 surrounds the suspension shaft 70 and has its opposite ends bearing against the pivot pin 142 and the cutter-actuating lever 42, thus serving the dual function of yieldingly biasing the lever 42 to its retracted position and of applying light spring tension to the gripper cradle 78 tending to urge the same in a counterclockwise direction as viewed in FIGS. 4 and 6 to the end that the gripper foot 16 will be yieldingly urged toward the gripper anvil 14 for strap-engaging purposes.

As shown in FIGS. 3 and 4, the cam 24 is provided with a laterally projecting hold-down pin 149 which is designed for cooperation with the latch 29 in latching the cam 24 in the lowered position in which it is shown in FIG. 8 for the purpose of maintaining the hold-down roller 20 in its elevated position out of contact with the tensioning wheel 18. The latch 29 is connected at its extreme lower end by a spring 150 (FIG. 5) to the lower region of the cradle 78, the spring thus serving to bias the latch 29 in a clockwise direction and to assist the spring 148 in biasing the cradle 78 in a counterclockwise direction. Normally, the pawl 29 yieldingly bears against the pin 149 under the influence of the spring 150. A notch 151 formed in the pawl allows the pawl to interlock with the pin 149 as shown in dotted lines in FIG. 5 when the cam 24 has been depressed by the lever 22 as the latter enters the range *c*. In this latched position of the cam 24, the tensioning wheel is maintained out of cooperative engage-

ment with the tensioning wheel 18 as previously set forth. In its latched position, the distal end of the latch 29 overlies the extreme end of the shoulder portion 94 of the lever 22 as shown in FIG. 8, and thus when the lever is swung upwardly in moving from the range *c* into the range *b*, the latch 29 is forcibly released from the pin 149.

As previously stated, the cutter-actuating lever 42 has its lower or proximate end pivotally connected to the transverse shaft 70. The medial region of the lever 42 is formed with a curved cutter-engaging finger 152 which overlies the upper end of the cutter blade 40. The upper or distal end of the lever 42 is formed with a lateral operating finger 153 which is conveniently accessible for lever manipulating purposes. As best seen in FIG. 4, the cutter blade 40 is slidably vertically in the cutter block 36 and a spring 160 maintains the cutter blade in an elevated retracted position. The cutter blade 40 is adapted to be depressed under the influence of the lever 42 against the yielding action of the spring 160 and, when so depressed, an inclined shearing edge 162 formed on the cutter blade cooperates with the forward edge of the gripper foot 16 to sever the strapping in the working area of the tool, and which extends through the slot 120 in the gripper block 36.

Referring now to FIGS. 3, 4 and 6, the cutter block 36 is provided with a laterally projecting kick-out pin 170 which projects outwardly from the lower regions of the inside face of the block and which underlies the pivot pin 142. Both the kick-out pin 170 and the pivot pin 142 are positioned in the path of movement of the leading edge 172 of the kick out cam 26 and are adapted to be engaged thereby during rocking movement of the cam under the influence of the shoulder 94 provided on the operating lever 22. The kick-out cam 26 is formed with a trailing edge region 174 which is engaged by the shoulder portion 94 of the lever 22 when the latter is disposed within the operating range *c*. A clearance slot 177 is formed in the medial region of the cam 26 and receives the tensioning wheel drive shaft 72 therethrough.

It is to be noted at this point that when the gripper foot 16 is seated squarely upon the strapping *S* as shown in FIG. 6, the pivot pin 142 is disposed a slight distance forwardly from the vertical plane passing centrally through the supporting shaft 70 and normal to the gripper anvil 14 so that a small angle is subtended between this plane and the inclined plane passing through the longitudinal axes of the shaft 70 and pin 142. This angle designated at θ in FIG. 6 is critical only within fairly wide limits and it has been found that an angle on the order of 87° will give optimum gripper action during strap-tensioning operations as will be described in detail when the operation of the strapping tool 10 is set forth. It is also to be noted that the spring 148 which, as previously stated, biases the gripper cage 78 in a counter-clockwise direction is a relatively light spring and its function is merely to hold the gripper foot 16 initially in seating engagement with the strapping *S*. This spring has little effect on the gripping action of the gripper foot 16, the effectiveness of the latter during tensioning of the strapping *S* being the result of a self-energizing gripping action which takes place automatically due to the relatively small approach angle θ and the magnitude of which is an inverse function of the sine of such angle.

In the operation of the strapping tool 10, the operating lever 22 is fully depressed in the range *c*, depression thereof being facilitated by a hand gripping operation wherein the lever 22 and reentrant arched portion of the base extension 56 are "squeezed" so to speak, utilizing the four fingers of the hand and the ball portion at the base of the thumb. During such depression, the shoulder 94 engages the cams 24 and 26 in the order named and causes them to be depressed or rotated in a clockwise direction as viewed in FIG. 8 so that they assume the position shown in this view. Initial depression of the cam 24 causes the latch pin 149 to interlock with the spring-biased

latch 29, thus maintaining the hold-down roller 20 out of engagement with the tensioning wheel 18 and also maintaining the gripper foot 16 elevated from the anvil 14. The tool is then loaded in the manner previously described so that the overlapping free end and feed end portions of the strapping pass through the slot 100 in the transverse wall 52 with the underlying or free end portion resting upon the rib 108 at the forward edge of the anvil 14 and with the feed end portion passing through the slot 120 in the gripper block and then extending around the underneath side of the tensioning wheel 18 and between this wheel and the hold-down roller 20. The operating lever 22 is then released and the gripper foot caused to seat squarely upon the strapping *S* under the influence of the spring 148.

The operating lever 22 is then forcibly moved through the range *b* and into the range *a* and, in so moving through the range *b* the shoulder 94 on the lever 22 engages the latch 29 as shown in FIG. 8 and releases the latch from the hold-down pin 149 so that the hold-down roller 20 will move into clamping engagement with the strapping on the tensioning wheel 18 under the influence of the spring 25 and will assume the position wherein it is shown in FIG. 6.

The strapping is now tensioned about the object *O* undergoing strapping by rocking the lever in the range *a* as previously set forth, the seal 44 applied and the lever 152 actuated to effect the cut-off operation, after which the severed strap 46 assumes the full line position in which it is shown in FIG. 7.

During the tensioning operation and prior to application of the seal 44, the tensioning wheel 18 serves to pull the excess portion 30 of the strapping *S* in the direction indicated by the horizontal arrow in FIGS. 7 and 9. Initially, and before the first stroke of the operating lever 22 is performed, the strapping extends loosely around the tensioning wheel 18 and, in the absence of an appreciable degree of pressure by the hold-down roller against the strapping on the tensioning roller, insufficient friction between the tensioning wheel and the strapping would be obtained so that upon rotation of the tensioning wheel the strapping would not be gripped thereby and no tensioning would take place. However, the yielding pressure exerted by the hold-down roller 20 upon the strapping *S* in the region of approximate tangency between these two generally cylindrical members is not excessive and it serves to clamp the strapping firmly in position against the tensioning wheel so that the several pointed protuberances 110 on the periphery of the wheel in this tangential region are caused to penetrate the strapping and afford at least one limited region of good frictional contact between the wheel and strapping at the commencement of the tensioning operation. Stated otherwise, the strapping *S* is pinched, so to speak, at the tangential region between the tensioning wheel 18 and hold-down roller 20 and then, as the tensioning wheel is rotated in the direction indicated by the arrow in FIG. 7, the slack in the excess portion 30 is first assimilated and thereafter the slack in the 180° wrap-around region on the tensioning wheel is progressively taken up until substantially all of the pointed protuberances 110 have penetrated the strapping and good frictional contact is made throughout this entire 180° region. It has been found that the pull on the strapping *S* which takes place after such 180° seating the strapping on the tensioning wheel has occurred is distributed on the surface of the tensioning wheel with diminishing effect from the point where the strapping initially contacts the periphery of the wheel over an arcuate extent of approximately 120° extending toward the region of contact with the hold-down roller 20. This diminishing frictional effect is a result of the elasticity of the strapping and has been schematically portrayed in FIG. 9 by the angle ϕ . Outside of the angle ϕ , the protuberances 110 exert practically no pulling effect on the strapping.

The initial pinching action occasioned by the hold-down roller 20 remains effective only momentarily until such

time as the strapping has become taut on the tensioning wheel in the 120° arcuate extent previously referred to. It will be observed that the hold-down roller rolls tractionally on the strapping and serves to feed the strapping away from the tensioning wheel. Penetration by a protuberance 110 at the region of tangency between the tensioning wheel and hold-down roller remains effective only momentarily as the tensioning wheel is rotated because continued rotation of the tensioning wheel and hold-down roller in opposite directions serves to eject such protuberance from its condition of strap penetration. However, as one protuberance 110 is thus ejected, the next adjacent protuberance is engaged by the hold-down roller and caused to penetrate the strapping so that a gripping action at the region of tangency between the wheel and roller is maintained until such time as all slack has been taken up and the strap-tensioning function is transferred to the arcuate region of contact between the strapping and tensioning wheel represented by the angle ϕ . Thereafter, the hold-down roller 20 functions merely as a strap guide to maintain general strapping direction and prevent the strapping from parting completely from the tensioning wheel. This "wrap-around" feature whereby the strapping is maintained in good frictional contact with the tensioning wheel constitutes one of the principal features of the present invention.

The action of the gripper foot 16 during strap tensioning and the manner in which this gripper foot is released from the strapping after the tensioning operation has been completed and the seal 44 applied has been fully set forth in the above-mentioned application, Serial No. 430,646, and reference may be had to such application for a full understanding thereof. It is deemed sufficient for purposes of description herein to state that upon release of the cam 24 by the shoulder 94, the gripper foot will seat squarely upon the strapping. During the tensioning operation, as tension is progressively attained, the pivot pin 142 will exert increasingly greater downward thrust upon the gripper block and the greater will be the clamping effect by the gripper foot which maintains a degree of stable equilibrium on the strapping. During the kick-out operation, as the shoulder 94 engages the cam 24, the leading edge 172 of the cam first engages the pivot pin 142 as shown in FIG. 6 and shortly thereafter engages the laterally projecting pin 170 to prevent tilting of the gripper block and avoid binding of the gripper foot on the strapping during elevation of the gripper block, all points on the underneath gripping surface of the gripper foot moving vertically in unison and thus releasing the strapping simultaneously. This kick-out action by the cam 24 constitutes the subject matter of the above-mentioned copending application.

During this kick-out action, the hold-down roller 30 is free from the tensioning wheel 18 as previously described and thus, with the gripper foot 16 and the hold-down roller 20 both being free from the strapping, the strapping tool 10 may be shifted bodily as a unit laterally so that the strap will be withdrawn from the slots 100 and 120 and from between the hold-down roller 20 and tensioning wheel 18.

The invention is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in this specification as various changes in the details of construction may be resorted to without departing from the spirit of the invention.

For example, whereas the tensioning method and apparatus disclosed herein has been illustrated in connection with a portable hand tool, it is to be distinctly understood that, if desired, the method and apparatus may be utilized in connection with power actuated tools whether the same be portable or in the form of a fixed installation.

Therefore, only insofar as the invention has particularly been pointed out in the accompanying claims is the same to be limited.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. In a strapping tool for tensioning a loop of strapping about an article, said loop having a free end portion and a feed end portion, a framework, means carried by the framework for fixedly clamping said free end portion against longitudinal shifting movement, and means for applying tension to said feed end portion, said means for applying tension comprising a strap-tensioning wheel having a cylindrical peripheral strap-engaging friction surface for receiving said free end portion at least partially therearound, means for rotating said tensioning wheel in a tensioning direction, a hold-down roller movable bodily toward and away from said tensioning wheel into and out of strap-clamping position and between which roller and wheel the feed end portion of the strapping is adapted to pass, and means for moving said hold-down roller.

2. In a strapping tool for tensioning a loop of strapping about an article, said loop having a free end portion and a feed end portion, a framework, means carried by the framework for fixedly clamping said free end portion against longitudinal shifting movement, and means for applying tension to said free end portion, said means for applying tension comprising a strap-tensioning wheel having a cylindrical peripheral strap-engaging friction surface for receiving said free end portion at least partially therearound and onto which the strapping is adapted to enter in tangential fashion, means for rotating said tensioning wheel in a tensioning direction, a hold-down roller movable bodily toward and away from said tensioning wheel into and out of strap-clamping position and between which roller and wheel the feed end portion of the strapping is adapted to pass, said roller, when in strap-clamping position, being engageable with the strapping at a point at least 45° circumferentially removed from the point of tangential entry of the strapping upon said friction surface and in the direction of strap tensioning, and means for moving said hold-down roller.

3. In a strapping tool for tensioning a loop of plastic strapping or the like about an article, said loop having a free end portion and a feed end portion, a framework, means carried by the framework for fixedly clamping said free end portion against longitudinal shifting movement, and means for applying tension to said feed end portion, said means for applying tension comprising a strap-tensioning wheel having a cylindrical peripheral strap-engaging friction surface for receiving said free end portion at least partially therearound and onto which the strapping is adapted to enter in tangential fashion, said friction surface being provided with a multiplicity of closely spaced sharp strap-penetrating protuberances thereon, means for rotating said tensioning wheel in a tensioning direction, a cooperating hold-down roller movable bodily toward and away from said tensioning wheel into and out of strap-clamping position at a point at least 45° circumferentially removed from the point of tangential entry of the strapping upon said friction surface in the direction of strap tensioning and between which roller and wheel the strapping is adapted to pass, and means for moving said strap-tensioning roller.

4. In a strapping tool for tensioning a loop of plastic strapping or the like about an article, said loop having a free end portion and a feed end portion, a framework, means carried by the framework for fixedly clamping said free end portion against longitudinal shifting movement, and means for applying tension to said feed end portion, said means for applying tension comprising a strap-tensioning wheel having a cylindrical peripheral strap-engaging friction surface for receiving said free end portion at least partially therearound and onto which the strapping is adapted to enter in a tangential fashion, the effective width of said friction surface against the strapping being substantially equal to the width of the strapping, said friction surface being provided with a multiplicity of sharp strap-penetrating protuberances thereon which are both transversely and circumferentially spaced from one another, means for intermittently rotating said strap-tensioning roller.

sioning wheel in a tensioning direction, a cooperating hold-down roller movable bodily toward and away from said tensioning wheel into and out of strap-clamping position at a point at least 45° circumferentially removed from the point of tangential entry of the strapping upon said friction surface in the direction of strap tensioning and between which roller and wheel the feed end portion of the strapping is adapted initially to be loosely inserted whereby, upon initial movement of the hold-down roller into strap-engaging position and subsequent rotation of the strap-tensioning wheel in a tensioning direction the hold-down roller will effect strap-penetration by said protuberances at said circumferentially removed point to feed the strapping away from the tensioning wheel and hold-down roller and take up the looseness in said feed end portion and thus tension the strapping against the tensioning wheel in wrap-around fashion throughout the arcuate extent existing between said point of tangential entry and said circumferentially removed point, thus causing the protuberances within said arcuate extent to penetrate the strapping in driving relationship, and means for moving said strap-tensioning roller.

5. The method of tensioning a loop of semi-elastic strapping about an article which comprises passing the free end of the strapping about the article and fixedly clamping the free end portion of the strapping against longitudinal shifting movement, partially wrapping the feed end portion of the strapping loosely around the circumference of a rotatable cylindrical friction surface, positioning a clamping roller in clamping engagement with the strapping on the friction surface at a region at least 45° removed from the point of tangential entry of the strapping onto said friction surface to establish driving frictional engagement between the friction surface and roller at said removed region, and thereafter rotating said friction surface in a tensioning direction to feed the strapping away from the tensioning wheel and roller and draw the loose strapping into tight coextensive frictional engagement with the tensioning wheel in the wrap-around region of the strapping whereby, due to its frictional engagement with the strapping, said wrap-around region will become effective to drive the strapping in a tensioning direction.

6. In a strapping tool for tensioning a loop of strapping about an article, said loop having a free end portion and a feed end portion, an anvil adapted to underlie said free end portion, a gripper member movable toward and away from said anvil into and out of clamping engagement with the strapping thereon, spring means yieldingly biasing said gripper member toward said anvil and thus into clamping position, a kick-out cam movable between a normal inoperative retracted position and an operative advanced position wherein it engages the gripper member and removes the same from the strapping, a rotatable strap-tensioning wheel having a peripheral friction surface engageable with the free end portion of the strapping, a hold-down roller movable toward and away from said strap-tensioning wheel between a normal operative advanced position wherein it is effective to engage the strapping and press the same against the strap-tensioning wheel and an inoperative position of strapping release, a hold-down cam movable between a normal inoperative retracted position and an operative advanced position wherein it is effective to maintain said hold-down roller in its retracted position of strapping release, and an operating lever having a cam-engaging shoulder thereon and movable in a first range of movement to rotate said strap-tensioning wheel in a tensioning direction and through a second range of movement wherein said shoulder thereon engages said hold-down cam and said kick-out cam and moves the same to their respective operative advanced positions.

7. In a strapping tool for tensioning a loop of strapping about an article, said loop having a free end portion and a feed end portion, an anvil adapted to underlie said free end portion, a gripper member movable toward and away from said anvil into and out of clamping engagement with the strapping thereon, spring means yieldingly biasing said gripper member toward said anvil and thus into clamping position, a kick-out cam movable between a normal inoperative retracted position and an operative advanced position wherein it engages the gripper member and removes the same from the strapping, a rotatable strap-tensioning wheel having a peripheral friction surface engageable with the free end portion of the strapping, a hold-down roller movable toward and away from said strap-tensioning wheel between a normal operative advanced position wherein it is effective to engage the strapping and press the same against the strap-tensioning wheel and an inoperative position of strapping release, a hold-down cam movable between a normal inoperative retracted position and an operative advanced position wherein it is effective to maintain said hold-down roller in its retracted position of strapping release, and an operating lever having a cam-engaging shoulder thereon and movable in a first range of movement to rotate said strap-tensioning wheel in a tensioning direction, through a second range of movement wherein said shoulder thereon engages said hold-down cam and moves the same to its operative advanced position, and through a third range of movement wherein said shoulder additionally engages said kick-out cam and moves the same to its operative advanced position.

8. In a strapping tool for tensioning a loop of strapping about an article, said loop having a free end portion and a feed end portion, an anvil adapted to underlie said free end portion, a gripper member movable toward and away from said anvil into and out of clamping engagement with the strapping thereon, spring means yieldingly biasing said gripper member toward said anvil and thus into clamping position, a kick-out cam movable between a normal inoperative retracted position and an operative advanced position wherein it engages the gripper member and removes the same from the strapping, a rotatable strap-tensioning wheel having a peripheral friction surface engageable with the free end portion of the strapping, a hold-down roller movable toward and away from said strap-tensioning wheel between a normal operative advanced position wherein it is effective to engage the strapping and press the same against the strap-tensioning wheel and an inoperative position of strapping release, a hold-down cam movable between a normal inoperative retracted position and an operative advanced position wherein it is effective to maintain said hold-down roller in its retracted position of strapping release, releasable latch means automatically operable upon movement of said hold-down cam to its operative advanced position to releasably maintain said cam in such advanced position, and an operating lever having a cam-engaging shoulder thereon and movable in a first range of movement to rotate said strap-tensioning wheel in a tensioning direction, through a second range of movement wherein said shoulder thereon engages said hold-down cam and moves the same to its operative advanced position, and through a third range of movement wherein said shoulder additionally engages said kick-out cam and moves the same to its operative advanced position, and means effective upon reverse movement of said operating lever from said second range of movement to said first range of movement for releasing said latch means.

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9. In a strapping tool, the combination set forth in claim 8, wherein said releasable latch means comprises a latch pin on said hold-down cam and a latch member movable into latching engagement with said pin during entry of the operating lever into the second range of movement, and wherein the latch-releasing means comprises a shoulder on said latch member positioned in the path of movement of said operating lever and engageable therewith during movement of the operating lever from said second range of movement into said first range of movement.

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