Dec. 1, 1959 J. H. LESLIE 2,915,004

HYDRAULIC TENSIONING CONTROL FOR POWER STRAPPING MACHINES

Filed April 9, 1958 5 Sheets-Sheet 1

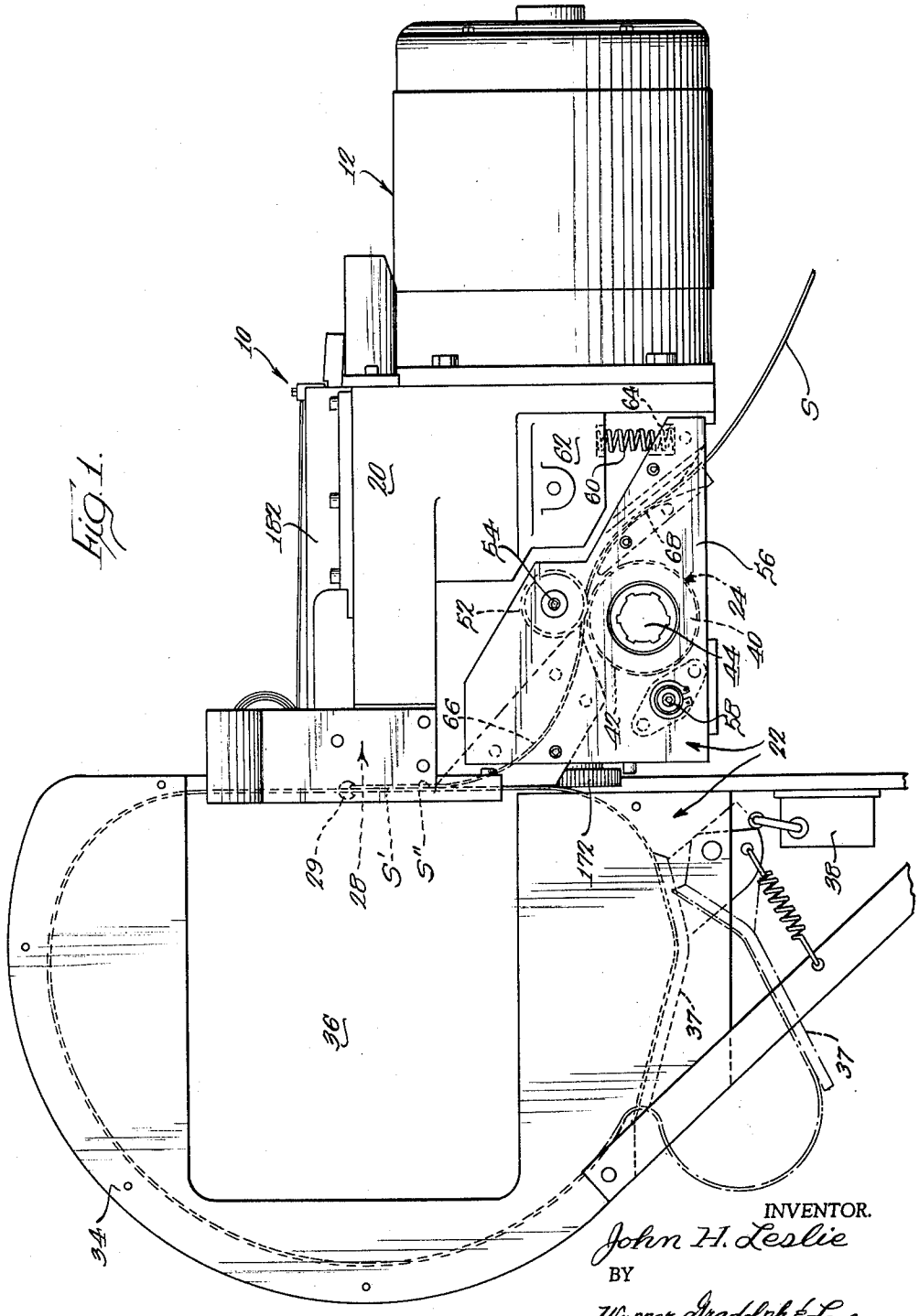


FIG. 1.

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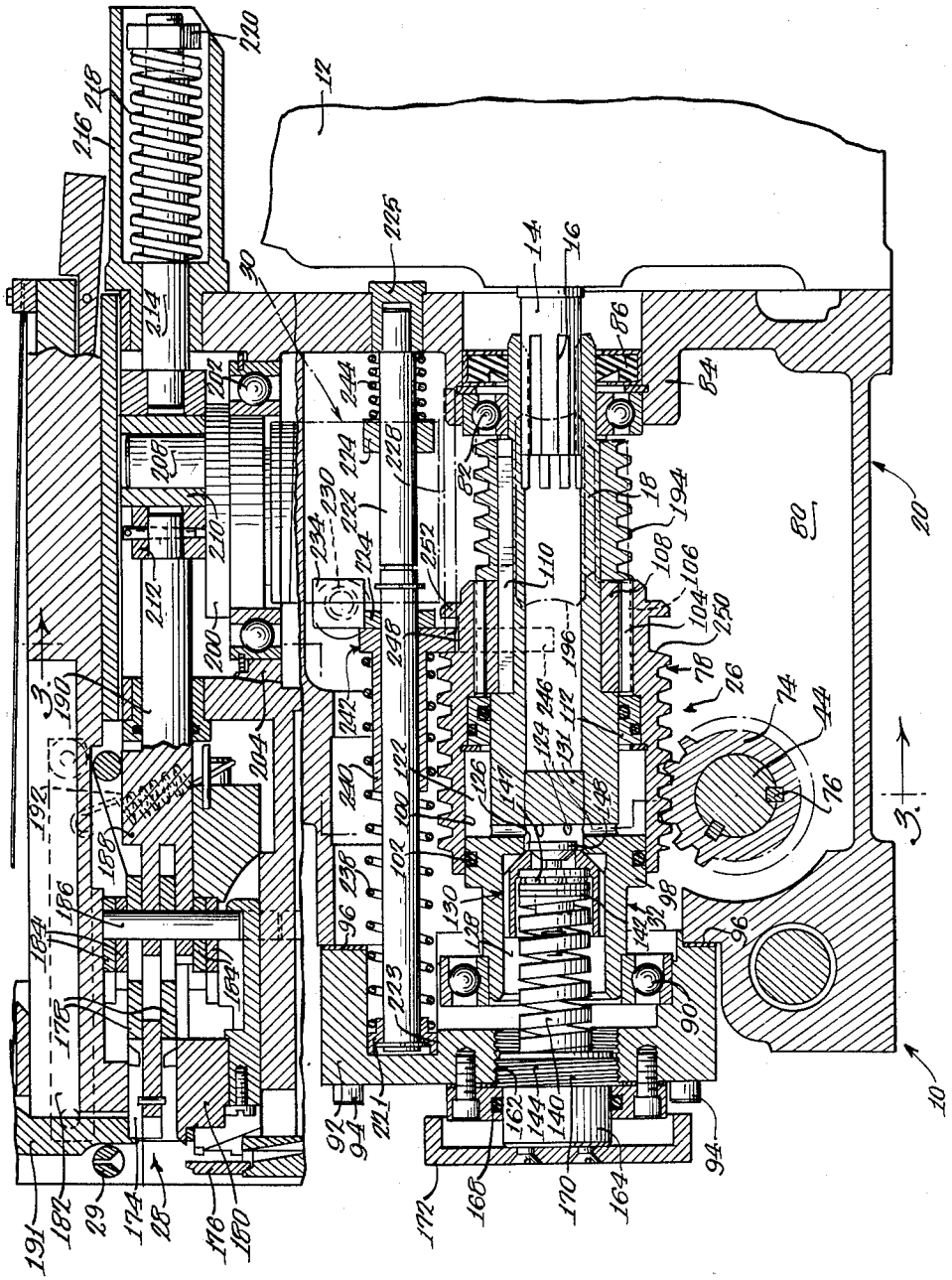


Fig. 2.

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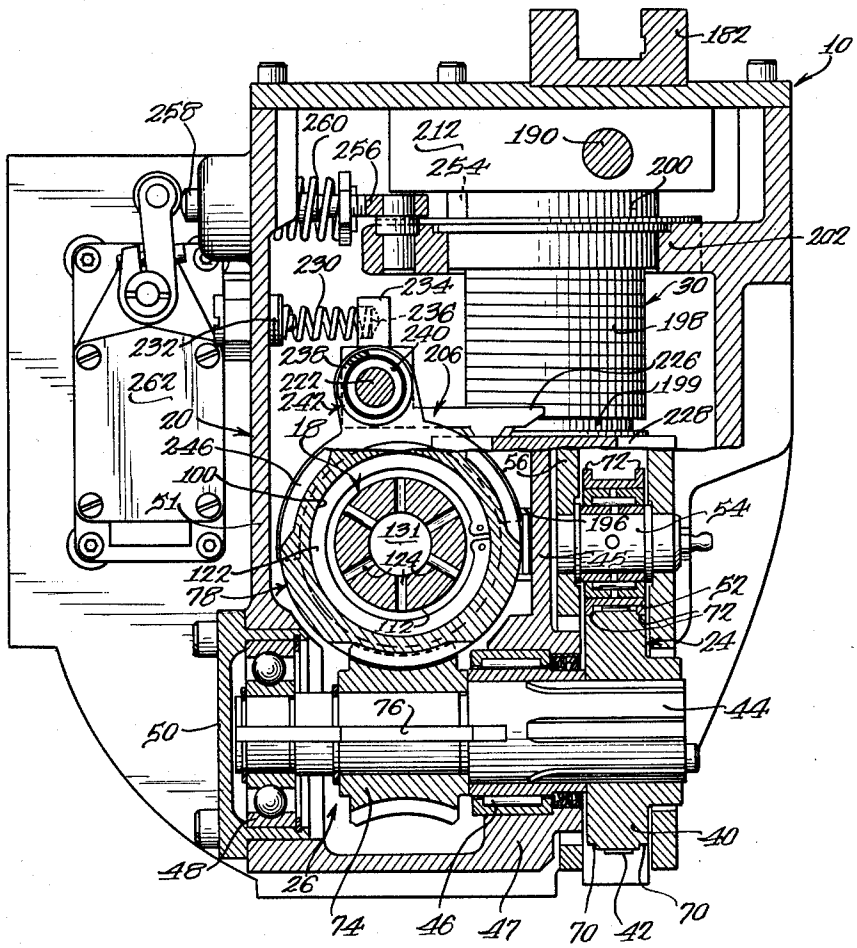


Fig. 3.

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HYDRAULIC TENSIONING CONTROL FOR POWER STRAPPING MACHINES

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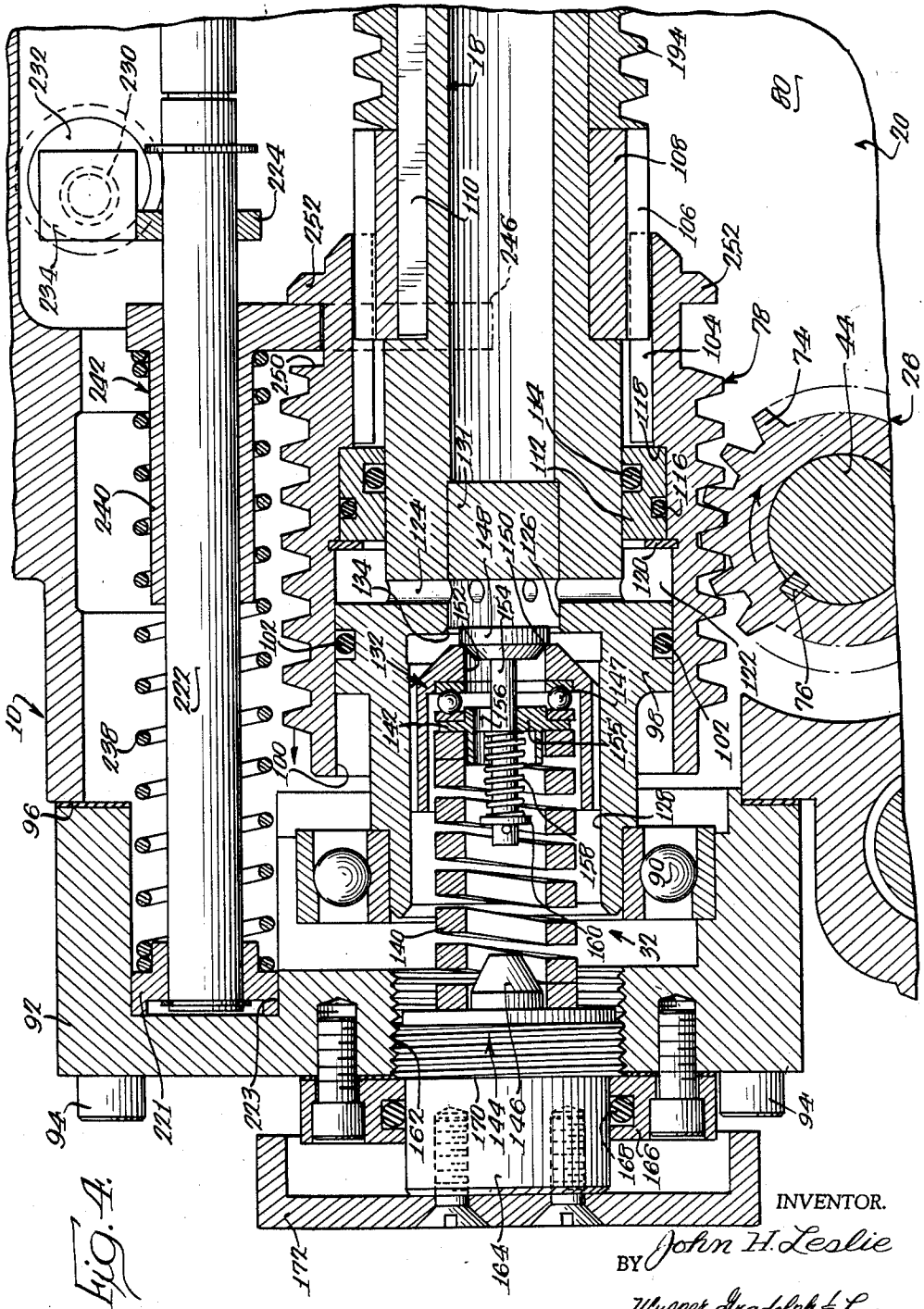


FIG. 4.

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HYDRAULIC TENSIONING CONTROL FOR POWER STRAPPING MACHINES

Filed April 9, 1958 5 Sheets-Sheet 5

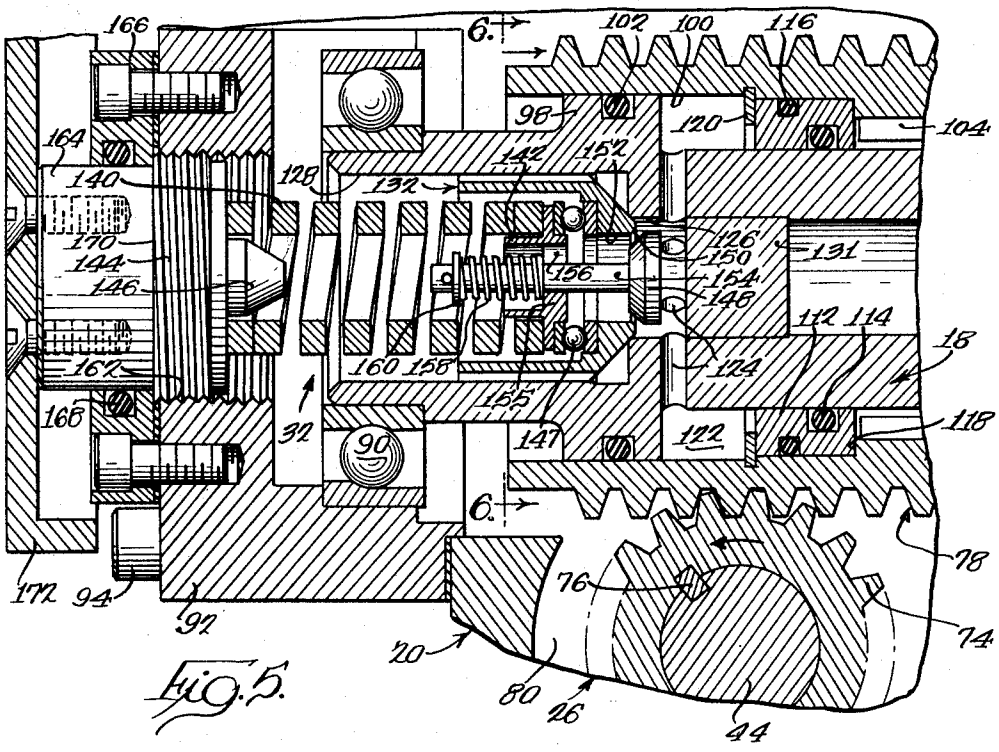


Fig. 5.

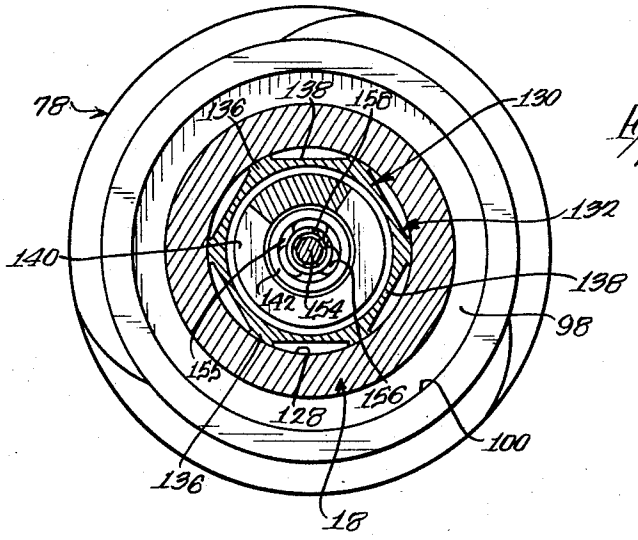


Fig. 6.

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United States Patent Office 2,915,004 Patented Dec. 1, 1959

2,915,004

HYDRAULIC TENSIONING CONTROL FOR POWER STRAPPING MACHINES

John H. Leslie, Winnetka, Ill., assignor to Signode Steel Strapping Company, Chicago, Ill., a corporation of Delaware

Application April 9, 1958, Serial No. 727,438

15 Claims. (Cl. 100—26)

The present invention relates to power strapping machines for binding bundles, bales, packages, coils, and the like, with a loop of tensioned strapping having its overlapping ends secured together in a tension resisting joint.

More particularly, this invention is concerned with a new and improved means for determining the maximum tension to be applied to the strapping looped about the bundle.

Machines of the class to which the present invention pertains operate to pass the strap about the bundle so that its free end is placed in overlapping position with the standing portion thereof, which is connected to the source of strap supply, usually a coil of strapping, either mounted in the machine or on a reel separate from but adjacent to the machine. The strapping is shrunk closely down about the bundle and a proper tension is applied thereto by the machine. When the tension in the strapping reaches a satisfactory value, the overlapping portions of the strapping and an embracing seal blank are united into a tension resisting joint, and the strapping applied to the bundle is severed from the source of strap supply. The means of the present invention for determining, controlling, and regulating the tension in the loop of strapping about the bundle is adapted for incorporation into machines of the foregoing type.

One problem encountered in power strapping machines is the difficulty of obtaining uniform tension in the strapping loop. Many factors contribute to this difficulty and to its solution, including the compressibility or lack thereof of the bundle being strapped, the shape of the bundle, the surface characteristics of the strapping with respect to the bundle, the inertia of the tensioning mechanism of the machine, and the certainty, or lack thereof, of response of the tension regulating mechanism in the machine to the tension in the strap about the bundle.

An important factor to consider when terminating the tensioning operation is that of dispelling the inertia of the tensioning mechanism. In powered mechanical machines this inertia resides in the tensioning wheel or other parts engaging the strapping, and all mechanisms, including its shaft, bearings, driving gears, worms, and parts connected to the tensioning wheel at the instant a predetermined tension has been applied to the strap encircling the bundle. It is, of course, obvious that the tensioning operation should cease at the instant the tension in the strapping reaches the maximum desired value. However, it is difficult to achieve this result when strapping a substantially incompressible bundle such as paper stacks or rolls, hardwood bundles, steel and other metal plate, and the like. It has been found that the point between a loose loop (too little tension) and broken strapping (too much tension) is extremely critical and, at times, is highly elusive.

This problem is particularly acute when the means for sensing the amount of tension in the strapping and responding to it to terminate the tensioning operation is

mechanical. Such mechanical means have inherent functional forces to overcome which prevent absolutely instantaneous operation, and thus they permit the inertia in the tensioning mechanism to carry the tensioning wheel through a further slight movement which might break the strap. Attempts to correct this fault by making the sensing means respond earlier in the cycle too frequently result in insufficient tension in the strapping, and therefore a loosely banded bundle.

Compressible or slightly compressible bundles, such as cotton bales, coils of wire and tubing, and like bundles, do not present such problems, but it is virtually impossible, for example, to adjust such power strapping machines properly to band coils of wire and skid loads of tinplate without carefully adjusting the strapping machines between operations on these two different types of bundles. This results in a certain amount of lost time in the packaging or bundling department if the same machine is used for bundling or tying all of the packages, or the majority thereof, shipped by a particular company.

It is, therefore, a principal object of the present invention to provide in power strapping machines for binding packages, bales, bundles, coils, and the like, with a band of tensioned strapping, a new and improved tensioning control mechanism which overcomes the above discussed disadvantages of the prior machines and devices.

It is another object to provide for power strapping machines a new and improved tensioning control mechanism which has a minimum number of parts with a minimum amount of weight subject to inertia at the instant the tension in the strapping has achieved the maximum desired value or a predetermined value close to the maximum value.

Another object is to provide a new and improved tensioning control mechanism for feed wheel type power strapping machines wherein the feed wheel may be stopped upon the reaching of predetermined tension in the strapping, while certain other parts of the drive mechanism can continue to operate without imparting additional tension to the strapping sufficient to break the strapping.

Another object is to provide a new and improved tensioning control for power strapping machines wherein, when the maximum or a predetermined strap tension has been reached, the machine is arranged to hold the tension during the formation of the joint in the strapping looped about the bundle and the severing of the bound bundle from the source of strap supply.

Another object is to provide a new and improved tensioning control mechanism for power strapping machines which is hydraulically controlled.

Another object is to provide a new and improved tensioning control mechanism for power strapping machines having means hydraulically responsive to predetermined strap tension which operates to retard driving of the strap engaging tensioning means by the power source, thereby to terminate the strap tensioning operation.

Another object is to provide a new and improved tensioning control mechanism for feed wheel type power strapping machines wherein means are provided to reduce the rotational speed imparted to the feed wheel even through the power source continues to drive at its former rate.

Another object is to provide a new and improved tensioning control mechanism for power strapping machines which has extreme accuracy in responding to strap tension and is readily adjusted when shifting from strapping or binding incompressible bundles to compressible bundles, and vice versa.

Other objects and advantages will become apparent

from the following description, taken in conjunction with the accompanying drawings, wherein

Fig. 1 is a side elevational view of a power strapping machine incorporating the tension control mechanism of the present invention;

Fig. 2 is a longitudinal sectional view, taken on two parallel planes, the lower portion of the figure showing the strap feeding and tensioning mechanism and the drive therefor, and the upper portion showing the joint forming mechanism and the drive therefor with portions in phantom lines;

Fig. 3 is a transverse sectional view, taken on the irregular line 3—3 of Fig. 2, looking in the direction of the arrows;

Fig. 4 is an enlarged fragmentary sectional view on the same plane as the lower portion of Fig. 2, showing the elements of the strap feeding and tensioning mechanism drive and the control therefor in the positions they assume after the strapping about the bundle has had a predetermined tension applied to it;

Fig. 5 is a fragmentary sectional view similar to Fig. 4, showing the positions of the strap feeding and tensioning mechanism drive and control elements as they move toward their normal or feeding and tensioning positions; and

Fig. 6 is a detailed view, through the valve structure, taken on the line 6—6 of Fig. 5, looking in the direction of the arrows.

The tensioning control mechanism of the present invention is particularly adapted for incorporation into a power strapping machine of the type disclosed and claimed in the copending application of George A. Crosby and Howard K. Otto, Serial No. 621,724, filed November 13, 1956, and assigned to the assignee of the present application. This specification will refer to the copending application for a complete description of a power strapping machine and for details of structure and operation not forming a part of the present invention.

The strapping machine **10** is powered by a reversible electric motor **12** which has its motor shaft **14** keyed or splined at **16** to the main drive shaft **18** of the strapping machine. The drive shaft **18** is mounted in a housing **20** which also houses or supports a strap guiding structure **22** (Fig. 1), a strap feeding and tensioning mechanism **24**, a drive **26** for the strap feeding and tensioning mechanism, a joint forming and strap severing mechanism **28** (Fig. 2), a drive **30** for the joint forming and strap severing mechanism, and a strap tension regulating mechanism **32** which is associated with the strap feeding and tensioning drive **26**.

Strapping S (Fig. 1) is drawn from a source of supply or reel (not shown) which may be of the type disclosed in the copending application of Robert C. Luth, Serial No. 505,945, filed May 4, 1955, and entitled "Strap Dispenser," and now issued into Patent No. 2,844,344, dated July 22, 1958, which is assigned to the assignee of the present invention and application. The strap S is drawn from the reel through the guide means **22** by the strap feeding and tensioning mechanism **24**, and is directed around a closed guide track or chute **34**, which has a bundle receiving opening **36** therein, so that the leading end S′ of the strap overlaps the standing portion S″ thereof in front of the joint forming mechanism **28** with its movement terminated by a removable barrier **29**. The guide or chute **34** may be of the type which opens or does not open, and for the purpose of the present invention this fact is immaterial. A better understanding of the present invention will be had if it be assumed that the strapping will be fed into the chute or guide **34** as the final portion of the machine cycle that is, after the bundle has been strapped and the joint formed in the overlapped strapping ends. Then, as the last operation in the cycle, the strap feeding mechanism **24** will fill the chute **34** for a subsequent banding operation.

During the strap feeding operation the motor **12** drives in a first direction, and when the strap feeding has been completed a switch **38** in the electric control circuit is operated by strapping pushing the chute section **37** to the phantom line position either to stop the machine, as at the end of a machine cycle, or to initiate a subsequent machine operation. In either case the motor **12** is restarted in the opposite direction to operate the joint forming mechanism **28** to clamp the free or leading end S′ of the strap and to anchor it against movement, and simultaneously to fold the wings or flanges of a seal blank loosely about the overlapping strapping portions S′ and S″ to preform the seal blank for the final joining operation. This preforming of the blank (which may be of the type shown in George A. Crosby Patent No. 2,710,435, dated June 14, 1955) is not sufficient, however, to prevent movement of the standing portion S″ of the strapping relative to the joint forming mechanism **28** and the anchored end S′ of the strapping.

At the same time the feeding and tensioning mechanism **24** is operated in the tensioning direction, first to shrink the loop of strap S about the bundle and then to apply tension thereto. The tension regulating mechanism **32** senses the instant at which the tension in the strap about the bundle reaches a predetermined value or the desired maximum value, or a value close to the latter, and it operates to retard or reduce the movement of the feeding and tensioning mechanism **24** and to release the joint forming mechanism **28** so that the latter may be further operated by its drive **30** to complete the joint in the overlapping strapping portions and embracing seal, to sever the strap about the bundle from the standing portion S″ thereof and to withdraw the joint forming mechanism **28** to its start or so-called "zero" position, thereby clearing the front of the machine for a subsequent strap feeding operation. When the joint forming and strap severing mechanism **28** has finished its operation, the machine either is shut off or operates as previously indicated to feed strap S to fill the strap guide or chute **34** to ready the machine for a subsequent bundle binding cycle.

The foregoing operations are more fully described and detailed in the copending application of George A. Crosby and Howard K. Otto, Serial No. 621,724.

The strap feeding and tensioning mechanism **24** includes a feed wheel **40** having a serrated periphery **42** which is mounted on the splined outer end of a feed wheel shaft **44**. The shaft **44** is journaled in the forward lower portion of the housing **20** on needle or roller bearings **46** carried in a boss **47** in a wall **45** of the housing and ballbearings **48** carried in a cap **50** bolted to the opposite wall **51** of the housing. The shaft **44** projects from the housing and suitable packing glands are provided to prevent leakage of lubricant.

The strapping S is held against the periphery **42** of the feed and tension wheel **40** by a pressure roller **52** which is freely journaled on a shaft **54** carried by a pair of spaced parallel plates **56** between which the feed and tension wheel **40** is also located. The plates **56** are rockably mounted on the housing at **58**, and a spring **60** which extends between a projecting portion **62** of the housing and a seat **64** carried by and between the plates **56** biases the assembly of the plates **56** and the pressure roll **52** in the clockwise direction about the pivot **58** and, therefore, urges the roller **52** toward the wheel **40** (Fig. 1). Suitable arcuate strap guides **66** and **68** are also carried by the plates **56** to increase the pressure of the strapping S against the periphery **42** of the wheel **40** during the strap tensioning portion of the machine cycle.

The feed and tension wheel **40** is provided with a pair of annular shoulders **70** which cooperate with flanges **72** on the pressure roll **52** slightly to space the tread of the pressure roll from the serrated periphery **42** of the feed wheel **40** when no strapping is present between the wheel and the pressure roll to prevent damage to the serrations on the feed wheel or to the tread of the pressure roller.

The feed wheel shaft 44 and the feed wheel 40 are driven by a worm wheel 74 which is keyed at 76 to the shaft 44 and which is in constant mesh with a worm 78 mounted on and driven by the drive shaft 18 and the motor 12.

The drive shaft 18 extends through a chamber and oil reservoir 80 in the housing 20 and at its inner end is journaled on ballbearings 82 carried in an inwardly projecting hollow boss 84 and against which the drive shaft is sealed by suitable packing 86. The motor shaft 14 projects through the boss 84 and has the splined connection 16 to the drive shaft 18 for the purpose of driving the latter in one direction or the other.

At its forward end the shaft 18 is supported in ballbearings 90 which are carried in a front closure casing 92 which is secured by bolts 94 to the front of the housing 20 and provided with a sealing gasket 96. It should be noted that the bearings 90 and 82 are carried between slight shoulders on the shaft 18, thereby inhibiting longitudinal shifting of the shaft.

The worm 78 is slidably carried by the shaft 18 on an annular piston-like projection 98 which receives a cylinder-like portion or bore 100 of the worm 78. The annular projection 98 is sealed against the bore wall 100 of the worm 78 by a sealing ring or gasket 102.

At its opposite end the worm 78 is formed with internal splines 104 which are slidably engaged with and mounted on external splines 106 formed on a spline carrier 108 which is nonrotatably mounted on the shaft 18 by means of a key 110. The inner end of the cylinder portion 100 of the worm 78 is closed by an S-shaped metallic sealing ring 112 which is sealed against the outer face of the shaft 18 by an O-ring 114 and against the inner cylindrical surface of the worm 78 by an O-ring 116. The sealing ring 112 is held between an internal shoulder 118 on the worm 78 and a split retaining ring 120 carried in an internal groove. The inner face of the piston portion 98 and the forward face of the sealing ring 112, together with the cylindrical wall 100 of the worm 78, form an oil or hydraulic fluid chamber 122 which communicates with the housing chamber or reservoir 80 through a plurality of radial ports 124, a longitudinal or axial port 126, and an enlarged passageway 128, the flow through which is controlled by a valve assembly 130. The hollow shaft 18 is closed adjacent the radial ports 124 by a plug 131.

The valve assembly 130 includes a hollow exhaust valve member 132 which is adapted to seal against a seat 134 at the port 126 and is provided with external vanes or ribs 136 (Fig. 6) slidably to support the exhaust valve member 132 in the cylindrical passage 128. The valve member 132 is provided with flatted faces 138 between the ribs or vanes 136 to define, with the wall of passage 128, passageways for the flow of hydraulic fluid or oil outwardly from the chamber 122 through the ports 124, port 126, and passageway 128 to the housing chamber or reservoir 80.

The valve member 132 is urged toward closed position against the valve seat 134 by a relatively heavy spring 140 which is confined between a retainer and valve stem guide 142 at its inner end and a tension adjustment screw 144 at its outer end. The adjustment screw is provided with a partially conical centering member 146 to hold the spring 140 properly aligned with the retainer 142 and the valve member 132. The spring retainer 142 bears against a ballbearing 147 seated against the inside of the head of valve member 132 to permit rotation of the shaft 18 and the valve assembly 130 relative to the spring 140.

The valve assembly 130 includes an inlet valve member 148 normally held against a valve seat 150 surrounding an axial port 152 in the head of the valve member 132 connecting the port 126 and the passage 128 through the hollow valve member 132. The valve member 148 is provided with a valve stem 154 which slidably projects through the combined spring retainer and valve stem guide 142 as best shown in Fig. 6, the guiding portion 155 of the retainer being provided with orifices 156 for the flow of oil from the passage 128 through the port 152, port 126, and ports 124, into the chamber 122. The valve member 148 is biased toward closed position by a relatively light spring 158 surrounding the projecting end of the valve stem 154 and retained between the guiding portion 155 of the retainer and guide member 142 and a washer 160 secured adjacent the outer end of the stem 154.

In order that the oil or fluid be drawn into the chamber 122, the reservoir 80 must be substantially filled.

Referring primarily to Figs. 2 and 4, it will be observed that when the worm 78 moves with lost or a reduced driving motion to the left from its normal position to an advanced position, the exhaust valve 132 opens slightly (the open position of valve 132 in Fig. 4 is probably exaggerated for better illustration). This changed position of the worm 78 and the opening of the exhaust valve 132 obtains when the tension in the strapping about the bundle reaches its predetermined or near maximum desired value, the tensioning wheel 40 being driven in the clockwise direction as seen in Fig. 1, and the shaft 44 similarly rotating in the clockwise direction as seen in Figs. 2 and 4 (although the shaft 44 has its rotational speed very substantially reduced or retarded when the valve 132 opens). When the tension reaches this predetermined value, the resistance to further strap movement increases, and when it increases sufficiently there is resistance to the worm 78 turning the worm wheel 74. As this occurs, the tendency is for the worm to move forwardly, or to the left as seen in Figs. 2 and 4, threading itself onto the worm wheel 74 to permit the latter to reduce its speed and even stop.

This movement of the worm is resisted or prevented by the oil which is trapped in the chamber 122 under the force of the spring 140 holding the valve 132 closed. However, when the pressure or forces tending to move the worm to the left reach a value consistent with the predetermined tension value in the strapping, the exhaust valve 132 cracks open under the pressures generated and against the closing force of the spring 140, and the driving ratio between the shafts 18 and 44 is changed so that the rotational speed of the shaft 44 is reduced and under certain conditions reaches zero speed.

As this occurs, the oil, under pressure from the movement of the worm 78 to the left or forwardly (Fig. 4), is expelled from the chamber 122 through the radial ports 124, the axial port 126, past the valve seat 134, and out through the passage 128 to the reservoir 80, flowing between the guiding ribs or vanes 136 on the exhaust valve 132. This forward threading movement of the worm 78 tends to rotate the worm wheel 74 in strap tensioning direction, thereby holding the tension on the strap about the bundle while the joint is formed in the overlapped strapping portions. The forward movement of the worm continues until the strapping is severed; after this, the worm continues to rotate in the same direction until the motor 12 is stopped or reversed.

The operation of the machine just described takes place in a fraction of a second, as elaborate tests have shown. This is one factor which aids in applying the desired tension to the strapping about the bundle as it is not possible appreciably to increase the strap tension once the valve 132 opens.

The tension which is imparted to the strapping may be increased or decreased by increasing or decreasing the force exerted by the spring 140 in holding the valve member 132 in closed position which determines the fluid pressure in the chamber 122 to be overcome before the worm can move forwardly. This is regulated by the tension adjusting screw 144 which is

threaded into a tapped opening 162 in the outer wall of the front housing or casing 92. The screw has a portion 164 projecting beyond the opening and through a closure plate 166 with which it has a fluid-tight seal at 168. The diameter of the screw as it passes through the plate 166 is less than the threaded portion of the screw, thereby providing a stop shoulder 170 cooperable with the plate 166 to prevent the screw from being completely removed from the front casing 92 and which acts as a limit on the reduction in compression which may be exerted by the spring 140. The screw is manipulated by an appropriate knob 172 which nonrotatably fastened to the outer end of the projecting portion 164 of the screw. It is quite clear, of course, that the maximum compression that may be applied to the spring is likewise limited by the distance which the screw may be turned inwardly against the force of the spring and the point at which the knob will contact the plate 166 or the front of the casing 92. It is thus possible to obtain a wide variation in the amount of tension which may be applied to the strapping about the bundle so that the maximum desired tension can be applied to the strapping regardless of the characteristic of the bundle which is being strapped, such as substantially incompressible bundles, as a load of sheet metal plate or very compressible bundles such as bales of cotton and similar material, or coils of wire. As a matter of fact, it has been found that since this tensioning control system responds instantly to full strap tension, since it operates without shock, and since the rotational inertia of the motor, the worm, and the drive shaft are smoothly absorbed, there is substantially no likelihood of breaking the strapping applied to the bundle and uniform tensioning results will be obtained regardless of the compressibility, or lack thereof, of the bundle being bound.

When the strap tension has reached its predetermined value, as hereinbefore described, the joint forming mechanism 28 is released for operation to form the joint in the overlapping strapping portions S′ and S″ and the embracing seal and to shear the standing portion S″ from the strap secured about the bundle. At the conclusion of the joint forming operation, and the retraction of the joint forming mechanism 28, the motor 12 is reversed to drive the worm 78 in the opposite direction. This causes the worm 78 to unthread itself across the worm wheel 74 and the condition of the tensioning control 32 during this operation is seen most clearly in Figs. 2 and 5 (the rotation indicated by the arrow in Fig. 5 will not obtain until the worm has returned to its normal position). The latter figure shows that the spring 140 has closed the valve member 132, seating it against the valve seat 134 and closing the port 126 from direct communication with the passageway 128. However, the movement of the worm 78 in the return direction or toward the right (Figs. 2 and 5) sucks oil or fluid from the chamber or reservoir 80 into the chamber 122. This is accomplished by opening the valve 148, thereby establishing communication between the chamber 122 and the reservoir 80 through the radial ports 124, axial port 126, port 152, the interior of the valve member 132, and the passageway 128. It should be noted that the spring 158 offers very little resistance toward opening of the valve member 148, and thus the flow of hydraulic fluid into the chamber 122 will be at a rate which is determined by the capacity of the ports and passageways through which it flows, and not by resistance to opening of the valve member 148. When the worm 78 has unthreaded itself to the position shown in Fig. 2, the valve member 148 will close under the force of the spring 158, and the worm wheel 74, the shaft 44, and feed wheel 40 will be driven in the counterclockwise direction to feed strap through the chute 34.

As more fully explained in the copending application of George A. Crosby and Howard K. Otto, Serial No. 621,724, and in George A. Crosby and Robert Frey Patent No. 2,801,558, the joint forming mechanism includes a pair of pivotally mounted jaws 174 which have the fourfold function of anchoring the end S′ of the strap against a stationary combined anchoring and cutoff block 176, folding the seal blank about the overlapping strapping portions S′ and S″, providing means to cooperate with slidable notchers 178 to deform the strapping portions and seal blank into the tension resisting joint, and holding the completed joint during the severing of the strap about the bundle from the standing portion S″ thereof by movement and action of a movable cutter 180 against the cutting edge of the stationary anchoring block and cutter 176. The jaws 174 are mounted for rectilinear and pivotal movement on guide pins (not shown) which are guided for movement toward and away from the joint forming position by appropriate guide means formed in the housing 20 and the underside of a seal blank storage magazine 182. At their rear ends the jaws are connected by links 184 to a common pin 186 which in turn connects them to a yoke 188 and a push rod 190, the latter being connected to the drive 30 for the joint forming mechanism. The seal blanks are stored in the magazine 182 and are advanced therefrom one at a time to a position between the jaws 174, when the latter are retracted, by a seal feed mechanism 191 which is powered by a pair of springs 192 (one shown).

The drive 30 for the joint forming mechanism 28 includes a worm 194 which is driven from the drive shaft 18 by the key 110. The worm 194 drives a worm wheel 196 (Fig. 2) which is connected to a drum 199 (Fig. 3) which is encircled by a spring clutch 198 (Fig. 3), one end of which is anchored in a driving member 200 which is pivotally journaled in a bearing 202 in a horizontal wall 204 of the housing. The other end of the spring which encircles the drum 199, which is separate from and independently rotatable from the driven member 200, is under the control of a shipper 206.

The driven member 200 has a crank pin 208 mounted thereon which drives a crosshead 210 mounted in a crosshead guide 212, the crosshead guide being connected to the push rod 190 for the joint forming mechanism 28. The crosshead guide 212 has a tail guide 214 connected to it which projects from the housing at the rear thereof into a casing 216 and is held by a spring 218 which operates against the inner end of the casing 216 and a nut 220 carried at the outer end of the tail guide 214.

The shipper 206 is slidably and rotatably mounted on a shipper shaft 222 by a pair of bearing members 224. At its forward end the shipper shaft 222 is mounted in a bushing 221 seated in a recess 223 formed in the inner face of the front casing 92. At its rear end the shipper is carried in a hollow bushing plug 225 pressed into an opening in the rear wall of the housing 20. The shipper 206 has its clutch spring controlling fingers 226 urged against a shipper shelf 228 by a spring 230 acting between a keeper 232 mounted in the housing wall 51 and a lug 234 upstanding from one of the bearings 224, the lug 234 having a recess 236 to receive the end of the spring 230. The shipper is biased toward the right (Fig. 2) by a front shipper spring 238 which surrounds the shaft 222 and tubular portion 240 of a shipper shifting yoke 242. The shipper 206 is biased toward the left, as seen in Fig. 2, and is normally held against the end of the shifting yoke 242 by a rear shipper spring 244. The spring 244 has sufficient strength to hold the elements normally in the position shown in Fig. 2. The shifting yoke 242 has a pair of arcuate legs 246 which semi-circularly embrace the tensioning mechanism worm 78 in an annular recess 248 formed between a pair of shoulders 250 and 252 at the inner end thereof.

When the worm 78 moves to the position shown in Fig. 4, the yoke 242 is moved to the left by the shoulder

252, thereby permitting the spring 244 to shift the shipper 206 to the left and release the spring clutch 198 to grab the drum. Thus, the driven member 200 and crank 208 are connected, through the spring clutch 198 and the driving drum 199, with the worm wheel 196, the worm 194, the drive shaft 18, and motor 12. This connects power to the joint forming mechanism 28 tightly to fold the preformed wings of the seal blank about the overlapped strapping portions, to notch the sandwich of strapping portions and seal blank, and to sever the strapped bundle from the standing portion S'' of the strapping. After the bundle has been strapped the joint forming mechanism returns to the start or "zero" position. When this occurs a lug 254 on switch actuating arm 256 drops into a notch (not shown) on the driven member 200, thereby permitting a switch operating plunger 258 which is biased against the arm 256 by a spring 260 to operate switch 262 in the control circuit. Actuation of this switch either stops the motor 12 or reverses it so that the machine 10 moves into the strap feeding portion of the cycle.

While the operation of the strapping machine as a whole can be understood from the foregoing description, a brief résumé will be set forth here.

Assuming that the strapping machine is of the type wherein the strap is fed into the chute 34 as the last operation in the cycle, the machine cycle then begins with the chute 34 loaded and the free end S' overlapped with the standing portion S'' at the front of the joint forming mechanism 28. The machine cycle is then started by closing an appropriate switch in the control circuit. The motor 12 is operated to rotate the drive shaft 18 in such direction that the tensioning mechanism shaft 44 is driven in the clockwise direction (Figs. 1, 2, and 4). This drive to the shaft 44 is through the worm 78, and the worm wheel 74, to the shaft 44 on which is fixed the tensioning wheel 40. Withdrawal of the strapping under tension causes, by means of the particular curvature of the guides 66 and 68, a pressure on the strapping so that it tends to rotate the plate 56 carrying the pressure roll 52 in the clockwise direction, thereby increasing the pressure of the strapping against the serrated periphery 42 of the wheel 40, to insure positive gripping action.

When the strap tension reaches a predetermined value according to the resistance offered by the spring 140, the torque exerted by the feed wheel 40 will increase to approach the maximum desired to be exerted. As resistance to an increase in strap tension increases, the driving movement of the feed wheel 40 is retarded and slows. This does not stall the motor 12, however, which continues to drive in the same direction and at the same speed, threading the worm 78 on the worm wheel 74 forwardly or to the left in the chamber 80, and against the pressure of the oil in the chamber 122. Some driving movement at a reduced rate is imparted to the worm wheel 74 and the feed wheel 40, thus increasing the driving ratio between the worm 78 and the worm wheel 74 while maintaining the torque exerted by the feed wheel.

This movement of the worm forces the oil under pressure from the chamber 122 to open the valve 132 against the tension regulating spring 140 and outwardly through the radial ports 124, axial port 126, and past the open valve 132, through the passage 128, and into the reservoir 80.

This movement of the worm forwardly moves the shipper shifting yoke 242 to the left to permit the rear shipper spring 244 to slide the shipper 206 to the left on the shipper shaft 222. The shipper fingers 226 release the lower end of the spring clutch 198 so that it tightly grips the drum 199 about which it is encircled and connects the drum 199, which rotates with the worm wheel 196, with the driven member 200. This, therefore, connects the crank pin 208 and crosshead 210 with the motor 12 so that the sealing mechanism 28 is operated to form the joint in the overlapping strap portions S' and S'' and seal blank and to sever the strapped bundle from the standing portion of the strapping and source of strap supply. Because the feed wheel 40 continues to exert maximum or near maximum torque during the joint forming and strap cutoff operations, no tension in the strapping about the bundle is lost.

The motor continues to operate in this direction for a short time until the joint forming mechanism 28 has been withdrawn, a seal blank has been fed to the jaws 172, and the switch 262 has operated. During this time the machine will tend slightly to unthread itself, that is, to withdraw the strapping downwardly through the strap guides 66 and 68 due to the further rotation of the feeding and tensioning wheel 40 in the clockwise direction (Fig. 1). However, as soon as the switch 262 is operated, the motor 12 is reversed and the machine begins its strap feeding cycle before the strapping has been completely unthreaded from the machine. The motor 12 then drives in the opposite direction, and the worm 78 drives in the opposite direction, thereby permitting the tensioning control elements to assume the positions shown in Fig. 5 without, however, rotating the worm wheel 74 and shaft 44. The valve 148 opens and fluid flows into the chamber 122 through the passage 128, the interior of the valve member 132, port 152, past the open valve 148, port 126, and radial ports 124. When the worm has completely restored itself to the position shown in Fig. 2, the valve 148 closes and the worm 78 drives the feed wheel 40 in the counterclockwise direction (Fig. 1) to feed strapping through the chute 34. When the chute has been completely filled, the switch 38 will be operated by the strapping pushing the chute section 37 to the phantom line position and the machine will terminate its cycle.

It is thus seen from the foregoing description that the objectives which were claimed for this invention at the outset of this specification have been fully attained.

While a preferred embodiment of the tensioning control mechanism for a power strapping machine constituting this invention has been shown and described, it will be apparent that numerous modifications and variations thereof may be made without departing from the underlying principles of the invention. It is therefore desired, by the following claims, to include within the scope of the invention all such variations and modifications by which substantially the results of this invention may be obtained through the use of substantially the same or equivalent means.

What is claimed as new and desired to be secured by United States Letters Patent is:

1. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power driven shaft, a worm slidably mounted on said shaft and driven thereby, a worm wheel engaged with said worm and driven thereby, said worm wheel being connected to said strap tensioning means so as to drive the same, means forming a fluid reservoir enclosing said shaft, said worm and said worm wheel, a piston formed on said shaft, a cylinder formed within said worm and telescoped over said piston so as to cooperate therewith to form a fluid chamber to retain fluid under pressure to restrain sliding movement of said worm on said shaft, a port in said shaft through which fluid may flow between said reservoir and said chamber, and valve means controlling the fluid flow through said port and operable to release fluid under pressure from said chamber into said reservoir to permit sliding movement of said worm on said shaft only when the tension of the strapping reaches

a value sufficient to retard the driving of said worm wheel by said worm.

2. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power driven shaft, a worm slidably mounted on said shaft and driven thereby, a worm wheel engaged with said worm and driven thereby, said worm wheel being connected to said strap tensioning means, means forming a fluid reservoir enclosing said shaft, said worm and said worm wheel, a piston formed on said shaft, a cylinder formed within said worm and telescoped over said piston so as to cooperate therewith to form a fluid chamber to retain fluid under pressure to restrain sliding movement of said worm on said shaft, a port in said shaft through which fluid may flow between said reservoir and said chamber, valve means controlling fluid flow through said port and operable to release fluid under pressure from said chamber to permit sliding movement of said worm only when the tension of the strapping reaches a value sufficient to retard the driving of said worm wheel by said worm, and adjustable spring means holding said valve means closed until the pressure of the fluid in said chamber builds up sufficiently to overcome the spring pressure and open said valve means.

3. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, a reversible strap feeding and tensioning means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto when operating in one direction and for feeding strapping when operating in the other direction, a reversible power driven shaft, a worm slidably mounted on said shaft, a worm wheel drivingly engaged with said worm connected to said strap feeding and tensioning means, hydraulic piston-cylinder means connected to said worm for resisting sliding movement of said worm on said shaft, first valve means for said piston-cylinder means and operable to release fluid therefrom to permit sliding movement of said worm in a first direction only when the tension of the strapping reaches a value sufficient to retard the driving of said worm wheel by said worm, second valve means for said piston-cylinder means and operable to permit fluid to flow thereto when said worm moves in a second direction, and a hydraulic fluid reservoir in communication with both said valve means.

4. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power driven shaft, a hollow worm having a cylinder forming portion slidably mounted on and driven by said shaft, a worm wheel drivingly engaged with said worm connected to said strap tensioning means, said shaft having a piston portion thereon positioned in said cylinder portion of said worm and with the latter forming a fluid chamber, and multiple valve means controlling the flow of fluid from and into said chamber, said valve means preventing flow of fluid from said chamber until said worm slides on said shaft whereby tensioning of the strapping about the bundle continues only until the tension reaches a value sufficient to retard the driving of said worm wheel by said worm.

5. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a reversible power element, a driving member coupled to and driven by said element and movable relative to said element in two directions, a driven member engaged with said driving member and driven thereby, said driven member being connected to said strap tensioning means to operate the latter, the driving ratio between said members being altered when said driving member moves in either direction relative to said power element, means forming a fluid reservoir enclosing said power element, said driving member and said driven member, a piston formed on one of said members, a cylinder formed on the other of said members and telescoped over said piston to cooperate therewith to form a chamber to retain fluid under pressure to restrain relative movement between said power element and said driving member, a port formed in one of said members through which fluid flows between said reservoir and said chamber, valve means controlling the flow of fluid through said port, and resilient means normally holding said valve means closed, whereby resistance above a predetermined value of said strap tensioning means to the operation thereof permits movement of said driving member in a first direction relative to said power element by opening said valve means to permit fluid under pressure to flow from said chamber thereby to effect an increase in the driving ratio between said members when the tension of the strapping about the bundle reaches a predetermined value.

6. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a reversible power element, a driving member coupled to and driven by said element and movable relative to said element in two directions, a driven member engaged with said driving member and driven thereby, said driven member being connected to said strap tensioning means to operate the latter, the driving ratio between said members being altered when said driving member moves in either direction relative to said power element, means forming a fluid reservoir enclosing said power element, said driving member and said driven member, a piston formed on one of said members, a cylinder formed on the other of said members and telescoped over said piston to cooperate therewith to form a chamber to retain fluid under pressure to restrain relative movement between said power element and said driving member, a port formed in one of said members through which fluid flows between said reservoir and said chamber, a pair of valve means controlling the flow of fluid through said port, and resilient means normally holding both said valve means closed, whereby resistance above a predetermined value of said strap tensioning means to the operation thereof permits movement of said driving member in a first direction relative to said power element by opening one of said valve means to permit fluid under pressure to flow from said chamber thereby to effect an increase in the driving ratio between said members when the tension of the strapping about the bundle reaches a predetermined value, and movement of said driving member in the second direction being permitted upon reversal of said power element by opening the other of said valve means to permit flow of fluid into said chamber thereby to restore the machine to strap tensioning condition.

7. In a machine for binding bundles and the like with a band of tensioned strapping, having means for guiding the strapping from a source of strap supply and about

the bundle so that a free end portion of the strapping overlaps a standing portion thereof, means for anchoring the free end portion of the strapping, reversible means engaging the strapping for feeding the strapping through said guiding means, for shrinking the strapping closely about the bundle, and for applying a tension thereto, means for forming a joint in the overlapping strapping portions, the combination comprising, reversible power means, means including a member having lost motion connecting said power means with the strap feeding and tensioning means, means including hydraulic means resisting the lost motion of said member until tension in the strapping about the bundle has reached a predetermined value, and means actuated by said member during its lost motion to initiate operation of the joint forming means only when the predetermined tension has been applied to the strapping about the bundle.

8. In a machine for binding bundles and the like with a band of tensioned strapping, having means for guiding the strapping from a source of strap supply and about the bundle so that a free end portion of the strapping overlaps a standing portion thereof, means for anchoring the free end portion of the strapping, reversible means engaging the strapping for feeding the strapping through said guiding means, for shrinking the strapping closely about the bundle, and for applying a tension thereto, means for forming a joint in the overlapping strapping portions, the combination comprising, a reversible drive shaft, means including a worm having lost motion relative to said shaft and a worm wheel connecting said shaft with the strap feeding and tensioning means, valve controlled hydraulic means resisting the lost motion of said worm until tension in the strapping about the bundle has reached a predetermined value, and means actuated by said worm during its lost motion to initiate operation of the joint forming means only when the predetermined tension has been applied to the strapping about the bundle.

9. In a machine for binding bundles and the like with a band of tensioned strapping, having means for guiding the strapping from a source of strap supply and about the bundle so that a free end portion of the strapping overlaps a standing portion thereof, means for anchoring the free end portion of the strapping, reversible means engaging the strapping for feeding the strapping through said guiding means, for shrinking the strapping closely about the bundle, and for applying a tension thereto, means for forming a joint in the overlapping strapping portions, the combination comprising, a reversible drive shaft, means including a worm driven and carried by said shaft and a worm wheel connecting said shaft with the strap feeding and tensioning means, said worm having lost motion relative to said shaft and said worm wheel, hydraulic means resisting the lost motion of said worm until tension in the strapping about the bundle has reached a predetermined value, and means actuated by said worm during its lost motion to initiate operation of the joint forming means only when the predetermined tension has been applied to the strapping about the bundle.

10. In a machine for binding bundles and the like with a band of tensioned strapping, having means for guiding the strapping from a source of strap supply and about the bundle so that a free end portion of the strapping overlaps a standing portion thereof, means for anchoring the free end portion of the strapping, reversible means engaging the strapping for feeding the strapping through said guiding means, for shrinking the strapping closely about the bundle, and for supplying a tension thereto, means for forming a joint in the overlapping strapping portions, the combination comprising, a reversible drive shaft, means including a worm driven and carried by said shaft and a worm wheel connecting said shaft with the strap feeding and tensioning means, said worm having lost motion in two directions relative to said shaft and said worm wheel, multivalve controlled hydraulic piston-cylinder means formed by said shaft and said worm resisting lost motion of said worm in a first direction until tension in the strapping about the bundle has reached a predetermined value, and means including clutch means actuated by said worm during its lost motion to initiate ate operation of said joint forming means from said drive shaft only when the predetermined tension has been applied to the strapping about the bundle, the lost motion in the opposite direction restoring said worm to its strap feeding and tensioning position relative to said shaft and said worm wheel upon reversal of the shaft at the end of the joint forming operation.

11. In a machine for binding bundles and the like with a band of tensioned strapping, having means for guiding the strapping from a source of strap supply and about the bundle so that a free end portion of the strapping overlaps a standing portion thereof, means for anchoring the free end portion of the strapping, reversible means engaging the strapping for feeding the strapping through said guiding means, for shinking the strapping closely about the bundle, and for applying a tension thereto, means for forming a joint in the overlapping strapping portions, the combination comprising, a reversible drive shaft, means including a worm driven and carried by said shaft and a worm wheel connecting said shaft with the strap feeding and tensioning means, said worm having lost motion relative to said shaft and said worm wheel, valve controlled hydraulic piston-cylinder means formed by said shaft and said worm resisting the lost motion of said worm until tension in the strapping about the bundle has reached a predetermined value, and means including clutch means acuated by said worm during its lost motion to initiate operation of said joint forming means from said drive shaft only when the predetermined tension has been applied to the strapping about the bundle.

12. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle with respect to a standing strapping portion, and a mechanism for forming a tension resisting joint in the overlapped strapping portions and a seal blank, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power element, a driving member coupled to and driven by said element, a driven member drivingly engaged with said driving member and connected to said strap tensioning means to operate the latter, said driving member being bodily movable relative to said power element and said driven member, means including clutch means connecting said power element with the joint forming mechanism when said clutch means is engaged, means including hydraulic means resisting movement of said driving member and sensitive to the resistance of said strap tensioning means to the operation thereof to permit said movement of said driving member and thereby to alter the driving ratio among said element and said members when the tension in the strapping about the bundle reaches a predetermined value, and means actuated by said driving member upon bodily movement thereof for effecting engagement of said clutch means only when the tension of the strapping about the bundle reaches said predetermined value.

13. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle with respect to a standing strapping portion, and a mechanism for forming a tension resisting joint in the overlapped strapping portions and a seal blank, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power element, a driving member coupled to and driven by said element, a driven member drivingly engaged with said driving member and con-

nected to said strap tensioning means to operate the latter, said driving member being bodily movable relative to said power element and said driven member, means including clutch means connecting said power element with the joint forming mechanism when said clutch means is engaged, means holding said clutch means out of engagement, means including valve controlled hydraulic piston-cylinder means resisting movement of said driving member and sensitive to the resistance of said strap tensioning means to the operation thereof to permit said movement of said driving member and thereby to alter the driving ratio among said element and said members when the tension in the strapping about the bundle reaches a predetermined value, and means actuated by said driving member upon bodily movement thereof to operate said clutch holding means to effect engagement of said clutch means only when the tension of the strapping about the bundle reaches said predetermined value.

14. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power driven shaft, an axially slidable worm mounted on and driven by said shaft, a worm wheel drivingly engaged with said worm connected to said strap tensioning means, pressure fluid means connected to said worm to resist sliding movement thereof, and a valve controlled orifice for said pressure fluid means to contain fluid therein until the tension of the strapping reaches a value sufficient to retard the drive of said worm wheel by said worm and said worm sliding on said shaft against the pressure of the fluid expelled through said orifice preventing reverse rotation of said worm wheel, thereby to maintain the tension in the strapping about the bundle.

15. In a machine for binding bundles and the like with a band of tensioned strapping, having means for holding a free end of strapping looped about a bundle in overlapped position with respect to a standing strapping portion, and means for forming a joint in the overlapped strapping portions, the combination comprising, means engageable with the strapping for shrinking the strapping closely about the bundle and applying a tension thereto, a power driven shaft, an axially slidable worm mounted on and driven by said shaft, a worm wheel drivingly engaged with said worm and connected to said strap tensioning means, hydraulic piston-cylinder means connected to said worm and containing a pressure fluid for resisting axial movement of said worm on said shaft, a valve controlled orifice for said piston-cylinder means and operable to release fluid under pressure therefrom to permit sliding movement of said worm only when the tension of the strapping reaches a value sufficient to retard the driving of said worm wheel by said worm, said worm rotating as it slides axially to prevent reverse rotation of said worm wheel and to maintain the tension in the strapping about the bundle, and means operable by said worm upon sliding movement thereof to initiate operation of said joint forming means to form a joint in the overlapping strapping portions while said strap tensioning means maintains the tension on the strapping about the bundle.

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