

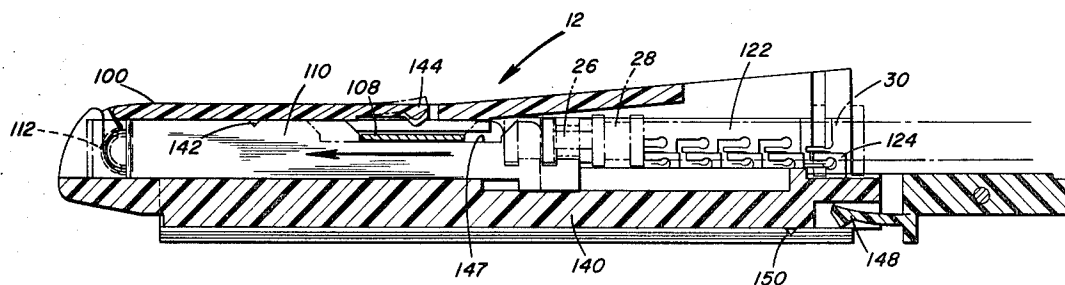
[54] **SUTURING AND DIVIDING ORGANIC TUBULAR STRUCTURES**[72] Inventors: **Douglas G. Noiles**, New Canaan; **Graham W. Bryan**, Ridgefield, both of Conn.[73] Assignee: **United States Surgical Corporation**, Baltimore, Md.[22] Filed: **Oct. 13, 1970**[21] Appl. No.: **80,451**[52] U.S. Cl. **128/305, 128/326, 29/243.57**[51] Int. Cl. **A61b 17/32, A61b 17/12**[58] Field of Search **128/305, 318, 319, 326, 334 R, 128/346, 324; 29/33.5, 243.57, 243.58, 211 R, 212 R; 227/19**[56] **References Cited****UNITED STATES PATENTS**

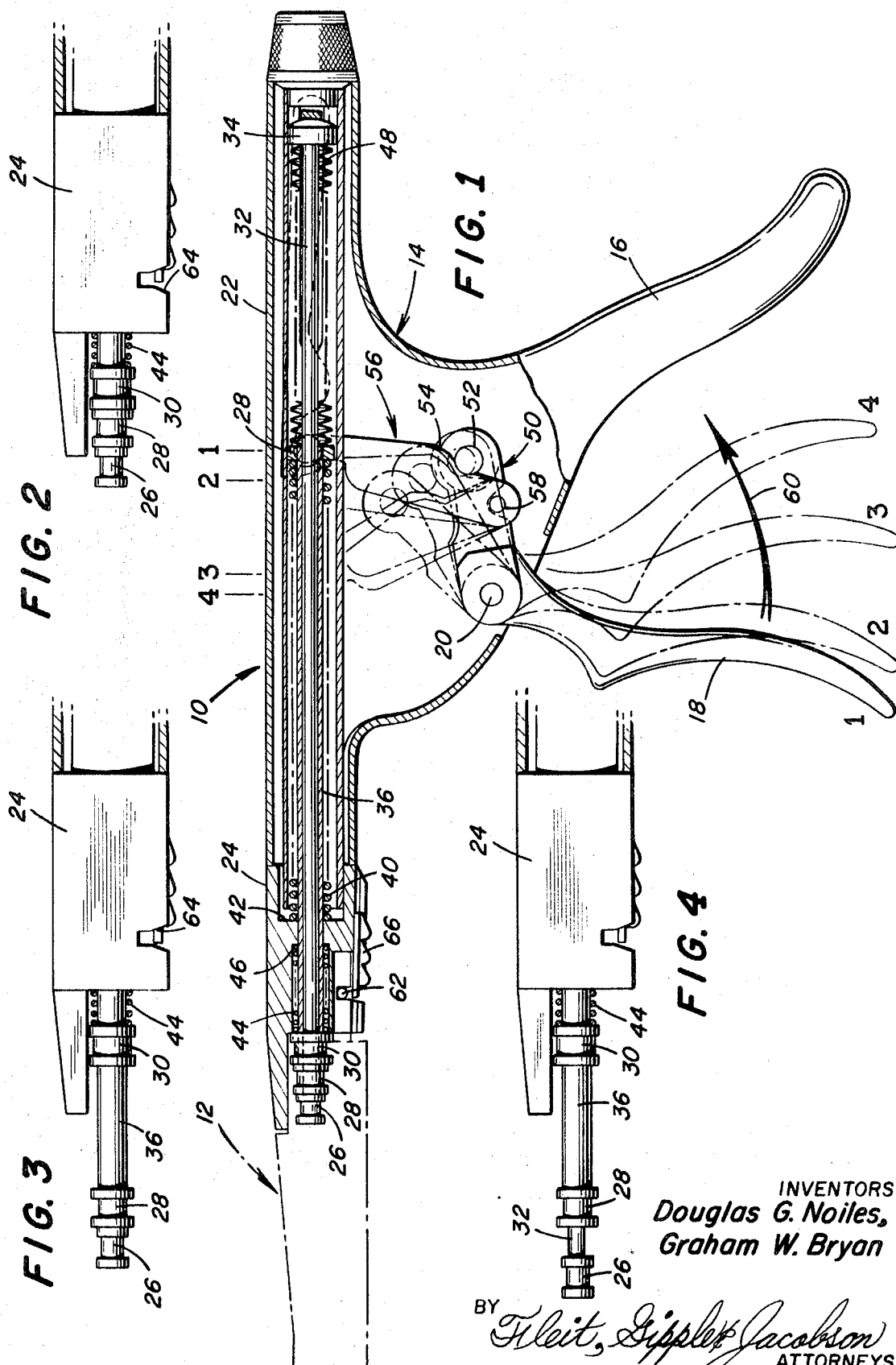
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Primary Examiner—Richard A. Gaudet*Assistant Examiner*—J. B. Mitchell*Attorney*—Fleit, Gipple & Jacobson[57] **ABSTRACT**

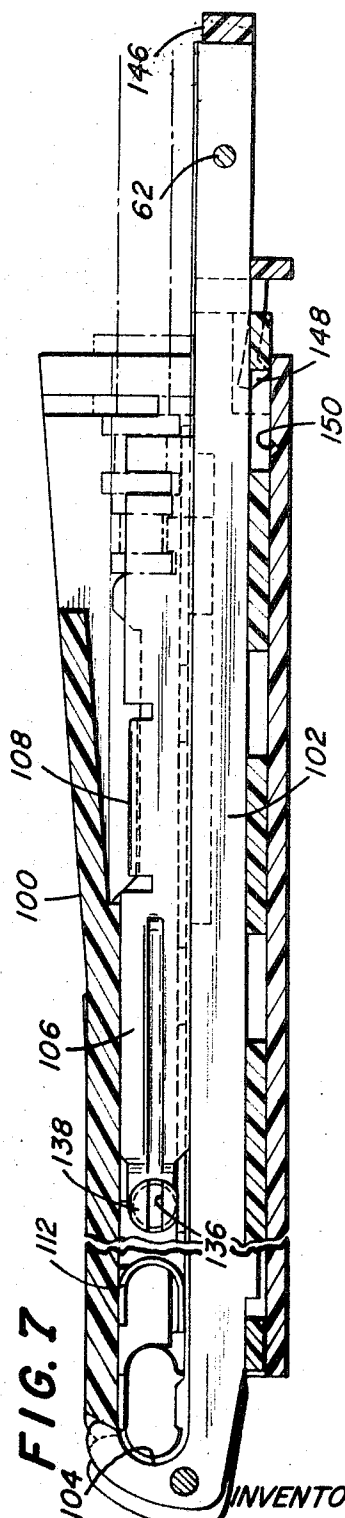
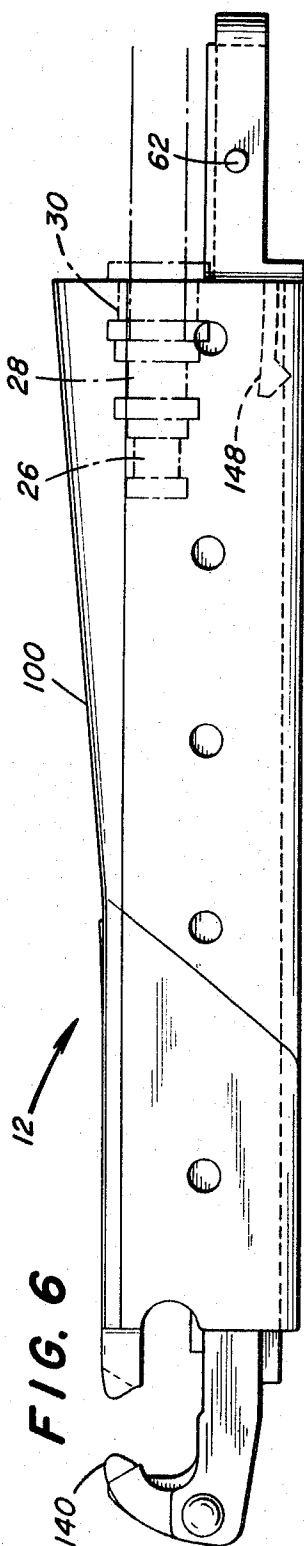
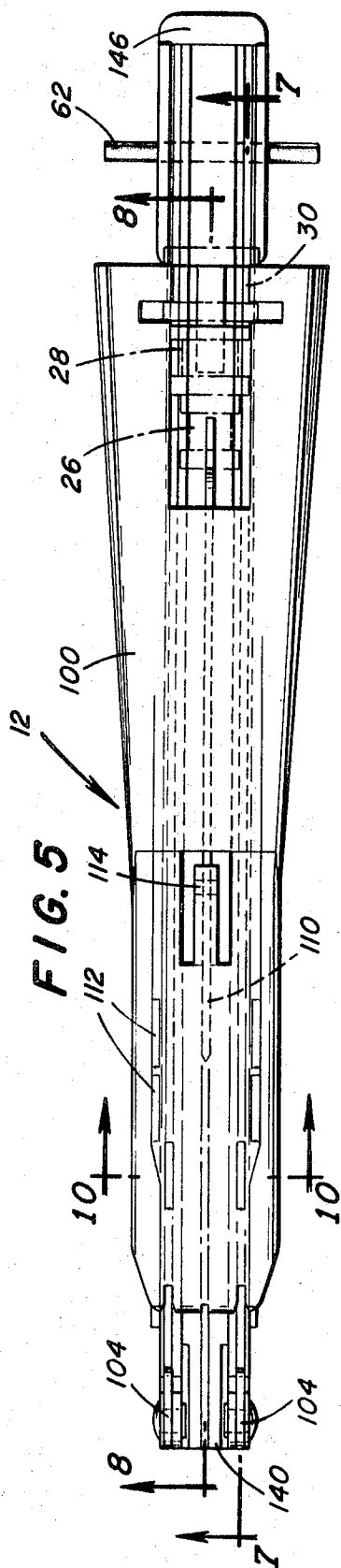
A cartridge and an instrument which, together serve to mechanically suture and divide organic tubular structures, such as blood vessels. The cartridge houses a plurality of staples and operates in three stages. After the tubular structure is inserted between the jaws of the cartridge, the cartridge jaws close, a pair of pushers come forward and suture the organic structure in two spaced locations with a pair of surgical staples, and a blade comes forward and divides the tubular structure at a position intermediate the two staples. The staples are indexed and readied for discharge by means of a pair of leaf springs which act between a fixed rail assembly and a movable wrap assembly. The instrument is adapted to coact with the novel cartridge and depends upon the interaction of three springs to bring about the three-stage operation of the cartridge.

19 Claims, 12 Drawing Figures



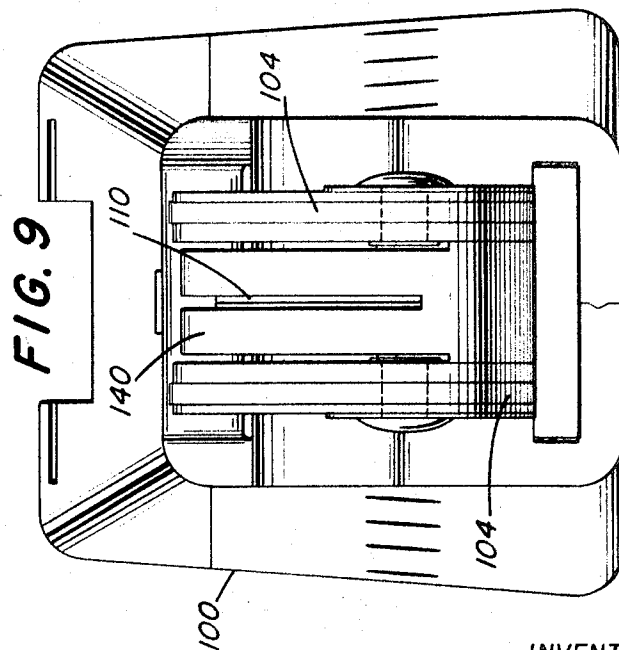
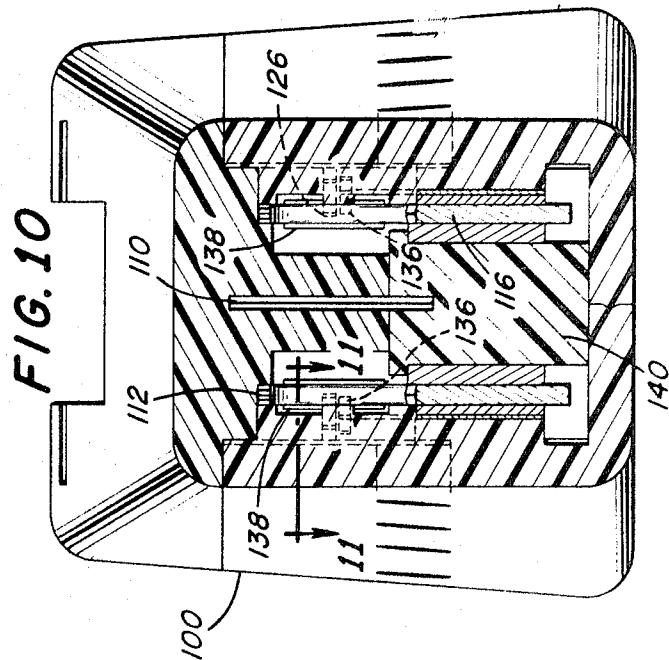
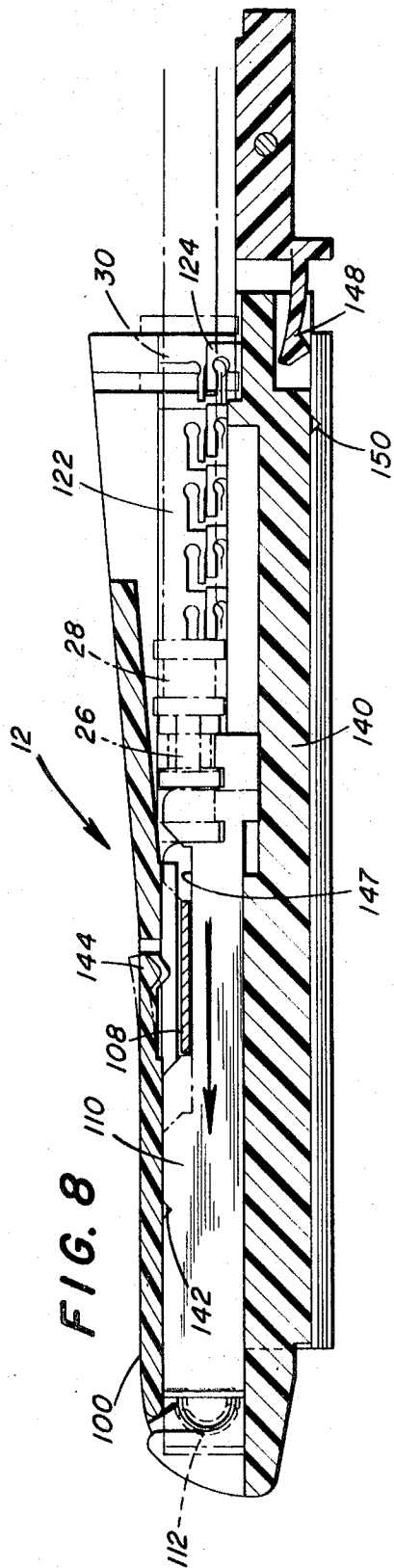
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SUTURING AND DIVIDING ORGANIC TUBULAR STRUCTURES

BACKGROUND OF THE INVENTION

In copending application Ser. No. 64,749 entitled METHOD AND CARTRIDGE FOR LIGATING ORGANIC TUBULAR STRUCTURES, and assigned to the present assignee, a novel method and cartridge for ligating, suturing and dividing organic tubular structures by means of surgical staples are disclosed. This copending patent application is directed, in part, to a cartridge which accepts an organic tubular structure and which mechanically encloses the tubular structure between its jaws, advances a pair of U-shaped staples toward the tubular structure by means of a pusher element and then surrounds the structure by the staples and crimps the staples in such a manner that the organic tubular structure is sealed at two spaced locations. Once the tubular structure is so sealed, a thumb-operated knife blade is moved forward to divide the structure intermediate the staples.

In the copending U.S. patent application noted in the preceding paragraph, a useful cartridge is disclosed. This cartridge, however, is the result of initial thoughts directed to a new concept. Accordingly, there are many areas where refinements of the initial concept can be made. For example, in that cartridge, only two staples can be housed, fed and crimped about the organic tubular structure. Since, in practical circumstances, a number of suturing and dividing operations must be made, it would be best if a plurality of staple pairs could be housed in the cartridge. Further, the dividing operation performed by the cartridge noted above is done by means of a thumb-operated knife blade. Therefore, with this cartridge, the surgeon is required to perform the suturing and dividing operations in two independent stages. Again, while such a configuration is workable, it is not the best possible configuration.

It is toward the refinement of the cartridge disclosed in the copending U.S. patent application noted above, and the elimination of the drawbacks associated therewith, that the present invention is directed.

SUMMARY OF THE INVENTION

The present invention relates to a cartridge and an instrument which, together are capable of mechanically and repetitiously ligating, suturing and dividing organic tubular structures, such as blood vessels and the like. The inventive cartridge houses a plurality of staple pairs, on the order of fifteen, and derives its power from the associated instrument.

The cartridge operates in three stages. Once the tubular structure is inserted within the area of its jaws, the cartridge wrap, or main body of the cartridge, is moved forward and toward an anvil assembly fixed on the instrument, thereby enclosing the tubular structure within the jaws of the cartridge. Then, a pair of pusher elements are advanced along their respective fixed rail assemblies and urge a pair of staples toward respective anvil assemblies. At the forward portions of the pusher strokes, the respective staples encircle the tubular structure at spaced locations and crimp about the structure in such a manner that the tubular structure is sealed at two locations. Finally, and with the pushers at the forwardmost portions of their strokes, a knife blade advances and divides the tubular structure intermediate the two staples. This three-stage operation is performed by a surgeon by simply squeezing the handle of the associated instrument.

The instrument, to operate the three-stage cartridge, is also of three-stage design. The forward end of the instrument is provided with three saddles which associate, respectively, with the cartridge wrap, the pusher and the knife. The forward end of the instrument is also provided with means for fixedly securing the rail assemblies of the cartridge to the instrument.

Three spring elements are housed in the instrument and, in conjunction with a cam and trigger element, operate the cartridge wrap, the pushers and three knife through three saddle elements. The instrument has a fixed handle and a handle

pivotally mounted with respect to the fixed handle. When the instrument handles are squeezed together, the movable handle pivots with respect to and moves toward the fixed handle. With a cartridge mounted on the instrument, the initial squeezing of the handle moves the cartridge wrap toward the fixed anvil assemblies, and the further squeezing advances the pushers toward the respective anvils and ultimately urges the knife toward the front of the instrument to effect a cutting operation.

Because of the three-stage operation, depending upon the interaction of three springs, the forces which need to be exerted on the handle vary with the handle depression. Further causing variance in the required operating forces are the distinct operations of the cartridge. To eliminate the distinct "feel" in the hand of the surgeon that differential forces are required of him, the inventive instrument is provided with a variable cam element operating between the power shafts of the instrument and the handle thereof. The cam surface is contoured in such a manner that the force required to operate the handle is relatively constant notwithstanding variations in the required force inputs to the cartridge. In this manner, the surgeon is unaware that three distinct stages of operation occur each time he activates the instrument.

The cartridge houses a plurality of staple pairs. When the cartridge is operated by the instrument, the staple pairs are indexed in a simple, effective and unique manner. When the cartridge is shipped, the forwardmost two staples are housed in the respective planes of the pushers, ready for ejection. The remaining pairs of staples are housed in the respective planes of a pair of guiding tracks. The staples are maintained in their respective tracks by having their arms biased against the track walls.

The staples in the guiding tracks are held fixed in the cartridge wrap during the first ligating, suturing and dividing operation. Only the forwardmost two staples are affected by the first operation, being ejected by the pushers. When, however, the cartridge wrap retracts from the anvil assemblies, after the first operation of the cartridge, a leaf spring assembly integral with each rail assembly, in turn integral with each anvil assembly, maintains the staples fixed with respect to the rail assemblies, thereby, in relative terms, advancing the staples in the cartridge wrap. During the retraction of the cartridge wrap, the forwardmost two staples are shifted from the respective planes of the guiding tracks to the respective planes of the pushers. When the cartridge wrap returns to its rearward position, the cartridge is ready for another firing operation.

As noted previously, all but the forwardmost two staples are held fixed in the cartridge wrap during the movement of the wrap toward the anvil assemblies. When the cartridge wrap moves forward, the staples are held fixed in the wrap by means of a second leaf spring assembly integral with each side of the cartridge wrap.

The novel cartridge, as noted previously, is shipped with a pair of staples ready for ejection. To ensure that the respective pushers are maintained in proper alignment for insertion on a powering instrument, and to prevent the respective pushers from accidentally ejecting their associated staples, the pushers are rigidly secured together and are held fixed with respect to the cartridge wrap until acted upon by the instrument. Similarly, during shipment, the knife is held fixed with respect to the wrap.

A further feature built into the inventive cartridge is an ejector mechanism by which mechanism the organic tubular structure, after having been sutured and divided, is forced out of the jaws of the cartridge. To this end, an ejector plate positioned intermediate the respective anvil assemblies, is made to move into the area of the anvil, to contact both segments of the divided tubular structure, and to urge the segments out of engagement with the respective anvil assemblies. In this manner, the surgeon need not make a conscious effort to ensure that the ligated and divided tubular structures are out of the jaws of the cartridge before retracting the cartridge from the operating arena.

Further to the above, the inventive cartridge is provided with transparent windows either on the sides thereof or on the top thereof, these windows being in the planes of the staples. In this manner, the surgeon can easily inspect the cartridge to ascertain the number of staple pairs remaining therein. The chance of a "wasted" stroke is thereby greatly diminished.

Accordingly, it is one object of the present invention to provide a cartridge for housing a plurality of staple pairs and adapted to mechanically ligate, suture and divide organic tubular structures with the aid of surgical staples.

A further object of the present invention is to provide a novel cartridge capable of ligating, suturing and dividing organic tubular structures and equipped with means for simply and reliably indexing a plurality of staple pairs.

Yet a further object of the present invention is to provide a novel cartridge for ligating, suturing and dividing organic tubular structures and equipped with simple leaf spring assemblies for advancing the staples in the cartridge.

A further object of the present invention is to provide a novel cartridge for ligating, suturing and dividing organic tubular structures and equipped with means to ensure that the cartridge may be shipped with misalignment of its elements or accidental discharge of its staples.

Still a further object of the present invention is to provide a relatively inexpensive and disposable cartridge for ligating, suturing and dividing organic tubular structures.

A further object of the present invention is to provide a novel cartridge for ligating, suturing and dividing tubular organic structures, the cartridge housing a plurality of staple pairs and being provided with means for easily recognizing the number of staple pairs remaining in the cartridge.

Yet another object of the present invention is to provide a three-stage instrument adapted to associate with a cartridge and to function, together with the cartridge, to ligate, suture and divide tubular organic structures.

Yet a further object of the present invention is to provide a simple hand operated instrument adapted for three-stage operation with the aid of three independent spring assemblies.

Still a further object of the present invention is to provide a novel instrument adapted to associate with a staple-housing cartridge, the instrument and cartridge together serving to ligate, suture and divide organic tubular structures, and the instrument being provided with cam means whereby the mechanical advantage associated with the instrument handle varies inversely with the forces necessary to bring about the cartridge operation.

These and other objects of the present invention, as well as many of the attendant advantages thereof, will become more readily apparent when reference is made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view, partially in section, of the surgical instrument forming a part of the present invention with its associated cartridge indicated in phantom;

FIG. 2 is a side view of the forward region of the inventive surgical instrument showing portions of the instrument when its trigger is in position 2 of FIG. 1;

FIG. 3 is a side view of the forward region of the inventive surgical instrument showing portions of the instrument when its trigger is in position 3 of FIG. 1;

FIG. 4 is a side view of the forward region of the inventive surgical instrument showing portions of the instrument when its trigger is in position 4 of FIG. 1;

FIG. 5 is a top view of the staple-carrying cartridge forming a part of the present invention;

FIG. 6 is a side view of the cartridge illustrated in FIG. 5;

FIG. 7 is a cross-section of the inventive cartridge taken along line 7—7 of FIG. 5;

FIG. 8 is a cross-section of the inventive cartridge taken along line 8—8 of FIG. 5;

FIG. 9 is a front view of the inventive cartridge;

FIG. 10 is a cross-section of the inventive cartridge taken along line 10—10 of FIG. 5;

FIG. 11 is a cross-section of the inventive cartridge taken along line 11—11 of FIG. 10; and

FIG. 12 is a side view of the ratchet assemblies when in the respective positions shown in FIG. 11.

DETAILED DESCRIPTION OF THE DRAWINGS

Before beginning an explanation of the inventive surgical instrument, and to enhance the understanding of the operation of the same, there follows a brief description of the operation of the inventive staple-carrying cartridge. As noted previously, the cartridge serves to successively ligate, suture and divide organic tubular structures. The main cartridge includes a main body portion slidable on a pair of fixed rail and anvil assemblies, a pair of pusher elements, and a knife blade. In carrying out its three-stage operation after the organic tubular structure is in position between the main body portion and the fixed anvil assemblies, the main body portion is moved forward until it abuts the fixed anvil assemblies and completely encircles the tubular structure within the jaws of the cartridge. Then, the pushers are activated, thereby ejecting a pair of staples from the main body and forming the staples about the organic tubular structure. After the staples are formed, the knife blade moves forward and divides the tubular structure at a position intermediate the staple locations.

During the cartridge operation described in the preceding paragraph, three distinct forces are required. First, the main body portion of the cartridge must be moved forward with respect to the fixed rail and anvil assemblies. Second, after the main body portion is in abutment with the anvil assemblies, the pushers must be driven forward to eject and form a pair of staples. And, third, once the staples are formed and the pushers are in their forwardmost positions of travel, the knife blade must be advanced.

With this background, the requirements of operation of the inventive instrument should be clear and the manner in which these requirements are met will be clear from the following. The inventive instrument is shown generally at 10 and has mounted thereon a cartridge 12. The instrument is defined by a main body portion 14 having a fixed handle 16, a handle 18 mounted for pivotable movement about a pin 20, a barrel 22 and a nose 24. Three saddle members 26, 28 and 30, respectively, extend from the nose 24 of the instrument 10 and are adapted to associate, respectively, with the cartridge knife, the cartridge pushers, and the cartridge main body. The forwardmost saddle 26 is integral with a solid tube 32 extending from the saddle 26 to the rear portion of the barrel 22. On the end of the tube 32 is a cap 34, the function of which will become clear from the following. The saddle 28 is integral with a hollow rod 36 which extends from the saddle 28 toward the rear portion of the barrel 22, terminating in a ring-like flange 38. The saddle 30 takes the form of a spool surrounding the hollow rod 36 and is free to slide therealong.

To bring about the three-stage operation of the instrument 10, in response to the required three-stage operation of the staple-carrying cartridge 12, the three saddles 26, 28 and 30 are controlled by the operation of the cartridge 12 and the interaction of three springs. A first spring 40 surrounds the hollow rod 36 and is maintained in compression between the ring-like flange 38 integral with the tube 36 and an inner wall 42 of nose 24. Spring 40 thereby biases the saddle 28 toward the nose 24 of the instrument 10. A second spring 44, in compression, surrounds the hollow tube 36, and acts between the rear wall of the saddle 30 and a front wall 46 of the nose portion 24. Spring 44 thereby serves to bias the saddle 30 away from the nose 24. The third spring 48 is located in the rear portion of the barrel 22 and acts in compression between the cap 34 integral with the rod 32 and the ring-like flange 38 integral with the rod 36 thus biasing the saddles 26 and 28 toward one another. Preferably, springs 40 and 44 are coil springs, whereas springs 48 take the form of Bellevill washers, or disc

springs. In view of their desired functions, the spring forces must be related as follows. Spring 44 exerts the least spring force, in the present example on the order of 4 pounds. Spring 40 exerts an intermediate amount of force, in the specific example on the order of 8 pounds. And, spring 48 is adapted to exert a force of on the order of 60 pounds.

As noted previously, the operation of the staple-carrying cartridge, and thus of the inventive instrument, is carried out in three-stages. And, due to the varying functions of the cartridge elements; distinct and varying forces are required to bring about each function. That is, while relatively little force is required to move the main body of the cartridge toward the fixed anvil assemblies, relatively large forces are required to bring about the formation of the staples. Again, only a small force is needed to advance the knife. In addition to the above, and because it is necessary to ensure that the three-stage operation of the staple-carrying cartridge follows the proper sequence, the spring forces associated with springs 40, 44 and 48 are not constant.

As a consequence of the above, the three stages of operation of the instrument, when associated with the cartridge, result in variations in input requirements. It should be apparent, therefore, that if no correcting provisions were made, the instrument would have peculiar characteristics from the standpoint of feel. To avoid these peculiar characteristics, the inventive surgical instrument is provided with a variable cam associated with a moveable handle 18, which cam is designed so that the three-stage operation of the cartridge is carried out with a relatively uniform input force exerted by the operating surgeon.

With continuing reference then to FIG. 1, it can be seen that an arm 50 continuous with the moveable handle 18 extends into the main body 14. A wheel, or disc, 52 is rotatably mounted on the end of the arm 50 and defines a cam follower. The cam follower 52 is adapted to roll along the camming surface 54 of a cam plate 56 pivotably mounted about a pin 58. While not shown, the upper region of the cam plate 56 is adapted to grip an extension associated with the cap 34 integral with the rod 32. These features are not shown, in order to avoid obscuring pertinent details of the instrument but are fully illustrated and disclosed in copending application Ser. No. 32,247, assigned to the present assignee. Suffice it to say that the cam plate 56 is biased in what may be termed a clockwise direction about its pin 58 by means of the interaction of the respective springs 40 and 48.

In operation, as the moveable handle 18 is urged in the direction of arrow 60, the arm 50 integral with the handle is caused to pivot about pin 20. As a result, the cam follower 52 is made to roll along the surface 54 of the cam plate 56 while the cam plate pivots about pin 58. This movement takes place against the continuous resistance developed by the respective springs 40 and 48. As can be seen in FIG. 1, the cam follower 52 engages the lower portion of the cam plate 56 when the moveable handle 18 is in the position 1. Then, the cam follower advances along the surface 54 until the moveable handle 18 is in its final position, position 4, at which time the cam follower 52 engages the upper portion of the cam plate 56.

As seen in FIG. 1, the surface 54 of the cam plate 56 has three main transitions. These transitions enable the instrument 10 to operate in such a manner that a relatively uniform input force may be exerted on the moveable handle 18 and so that this relatively uniform force may be transformed to forces of varying degrees of intensity to carry out the three-stage operation of the cartridge 12 without the surgeon being aware of such three-stage operation. Therefore, the distances between the transitions are set in such a manner as to correspond to the desired length of thrust of the saddles 26, 28 and 30. Similarly, the shape and slope of the transitions are designed so that the mechanical advantage associated with the handle-cam-drive rod assembly varies the forces delivered to the cartridge 12 under conditions of the uniform force delivery to the handle 18.

Now, with continuing reference to FIGS. 1 through 4, the operation of the inventive instrument 10 will be described. With the moveable handle in the position 1, the ring-like flange 38 lies in its rearwardmost position in the barrel 22, and the instrument is relaxed. When, however, a force is exerted on the moveable handle 18, causing the handle 18 to pivot into position 2, the cap 34, integral with the rod 32 and connected to the upper region of the cam plate 56, moves toward the nose 24 of the instrument 10. In view of the relatively large force exerted between the cap 34 and the ring-like flange 38, by the 60 pound spring 48, the ring-like flange 38 moves with the cap 34 into position 2. Hence, the spring 40 is compressed. At the same time, due to the action of the spring 44 which urges the saddle 30 away from the nose of the instrument 10, the saddle 30 moves the saddles 26 and 28 away from the nose 24. In this manner, the cartridge main body portion, the pushers and the knife move, in unison, away from the nose 24.

As is fully explained in copending U.S. Patent Application Ser. No. 32,247, noted above, the rail assemblies and anvils of the cartridge 12 are fixedly secured to the nose 24 of the instrument 10 by means of a pin 62 integral with the rail assemblies and anvils, which pin fits into groove 64 in the nose 24 and is secured therein by a thumb-operated lock 66. With the rails and anvil assemblies held fixed with respect to the instrument 10, and with the cartridge main body portion, the pushers and the knife moving away from the nose 24, the main body portion of the cartridge 12 closes upon the fixed anvil assemblies as will be described below. Position 2 of FIG. 1 shows the instrument when the main body portion just touches the anvil assemblies.

When the main body portion of the cartridge 12 comes into contact with the fixed anvil assemblies, no further movement of the saddle 30 may take place. Then, further rotation of the moveable handle 18 in the direction of arrow 60 results in the saddles 26 and 28 moving, in unison, away from the then fixed saddle 30. In its extreme position during this stage of operation, the handle moves into position 3 shown in FIG. 1, and the respective saddles take the positions shown in FIG. 3.

The elements move into position 3 as follows. As noted previously, when the main body portion of the cartridge 12 contacts the fixed anvil assemblies, no further relative motion between these elements is allowed to take place. Therefore, all relative motion between the nose 24 of the instrument 10 and the saddle 30 is terminated. However, with further rotation of the moveable handle 18, a force is exerted on the cap 34 and is directed toward the nose 24 of the instrument 10. This force moves against the spring 40 and results in continued movement of the saddles 26 and 28. There is no relative movement between these saddles because the large spring 48, requiring 60 pounds of compression, remains fully extended, with the 80 pound spring 40 then being compressed.

When the instrument is in position 3, the knife associated with the saddle 26 and the pushers associated with the saddle 28 have moved toward the fixed anvil assemblies of the cartridge 12, with the pushers then having completed the bending of the respective staples. At this time, the pushers have reached their forwardmost stroke, having fully crushed the respective staples and now in effect abutting the fixed anvil assemblies. Accordingly, both saddles 28 and 30 are in their fully extended positions. Further rotation of the moveable handle 18 in the direction of arrow 60 accordingly acts against the 60 pound spring 48 and causes the saddle 26 to move away from the saddle 28. In its ultimate position, position 4, the knife has moved to its full forward position and has divided the already ligated organic tubular structure. The ultimate positions of the respective saddles are shown in FIG. 4.

From the above, it should now be appreciated that the forces required to operate the elements of the staple carrying cartridge 12 in their proper sequence, control the movement of the respective saddles in response to forces exerted on the moveable handle 18. And, since the surface 54 of the cam plate 56 is developed as described above, the differential forces associated with the three springs and the three opera-

tions of the cartridge are substantially masked from the standpoint of the surgeon. Therefore, with the inventive instrument, a surgeon is able to automatically, easily and comfortably carry out three distinct surgical operations in a minimum amount of time.

With reference now to FIGS. 5 through 12, the construction and operation of the novel staple-carrying cartridge will be described. The cartridge 12 comprises a main body portion 100 which is slidably mounted on a pair of rail assemblies 102 adapted to be fixedly secured to the instrument 10. A curved anvil assembly 104 is defined in the forwardmost region of each rail assembly 102. A pair of pusher elements 106, rigidly secured together by means of a bridge 108, slide within the main body portion 100. A knife 110, centrally located in the main body portion 100 slides between the respective pushers 106 and is adapted to divide the organic tubular structure after the pushers 106 have completed their strokes and have effected the suturing of such structure. As can be seen best in FIGS. 6 through 8, the respective saddles 26, 28 and 30 positively control the movements of the knife 110, the pushers 106 and the main body portion 100 with respect to the rail assemblies 102 rigidly secured to the surgical instrument 10 by means of the pin 62 and the thumb-operated lock 66. Thus far, except for the automatic operation of the knife 110, the cartridge 12 functions in a manner identical with the operation of the cartridge disclosed in copending application Ser. No. 32,247, noted above.

As seen best in FIG. 11, a plurality of staples 112 are guided in one of two guide tracks on each side of the cartridge 12. For simplicity of description, only one side of the cartridge will be mentioned, but it should be understood that the cartridge is symmetrical about its centerline.

A number of staples 112 lie along the major portion of the length of the cartridge 12 in what may be termed an index guide rail 114. It is in the index guide rail 114 that the staples are, in unison, advanced toward the anvil assemblies 104 in readiness for ejection. Near the forward end of the cartridge 12, the staples 112 are transferred to an ejection guide rail 116. For purposes of transferring the staples from the index guide rail 114 to the ejection guide rail 116, the main body portion 100 is provided with a first ramp 118 which acts on the individual staples at their respective cross-pieces and a second ramp 120 which acts on the individual staples at the respective forward ends thereof. As can best be seen in FIG. 11, each pusher 106 is guided by and rides in the ejection guide rail 116.

The cartridge 12 is provided with a novel staple feeding arrangement. As seen best in FIG. 11, the novel staple feeding arrangement takes the form of a pair of interacting leaf spring assemblies. A first leaf spring assembly is designated 122, is fixedly secured to the main body portion 100, and has its leaves extending into the plane of an index guide rail 114. The second leaf spring assembly is designated 124, is fixedly secured to the rail assembly 102, and has its leaves also extending into the plane of an index guide rail 114. The forwardmost leaf 126 of the leaf spring assembly 122 is spring biased into the plane of the ejection guide rail 116, for reasons which will become clear from the following. Similarly, the forwardmost leaf 128 of the leaf spring assembly 124 is formed into an "L" and extends into the plane of the ejection guide rail 116. And, as can be seen best in FIG. 12, the leaves of the leaf spring assembly 124 are adapted to contact the staples 112 at positions lower than the leaves of the leaf spring assembly 122.

The operation of the inventive staple-drive mechanism is as follows. When the cartridge 12 is shipped, the forwardmost two staples are positioned as shown in FIG. 11. As noted previously, during shipment, the main body portion 110 is retracted and spaced from the anvil assembly 104. Upon initial activation of the associated surgical instrument 10, the main body portion 100 moves in the direction of arrow 130. With such movement of the main body portion 100, the respective leaves of the leaf spring assembly 122 come into contact with the individual staples 112 and carry such staples

forward in unison with the main body portion 100. During this movement, the staples 112 remain in the plane of the index guide rail 114.

It will be noted that a staple 112 is shipped in each ejection guide rail 116, in the plane of the pusher 106 and is thus in readiness for ejection and forming around the anvil assembly 104. After the main body portion 100 has come into contact with the anvil assembly 104, as mentioned above, the pushers 106 begin their forward movement relative to the main body portion 100 and contact the respective forwardmost staples 112, eject the same from the main body portion 100 and form same around the organic tubular structure housed within the jaws of the cartridge 12. Then, once the organic tubular structure is sutured, the knife 110 is made to advance and to divide such structure intermediate the pair of suturing staples 112. During this forward movement of the pushers 106 relative to the main body portion 100, all staples but the forwardmost staples remain fixed in the main body portion.

Once a pair of staples have been ejected and formed, and the organic tubular structure has been divided, the knife, the pushers and the main body portions are ready to be retracted from the region of the anvil assemblies. First, the knife retracts, then the pushers retract and finally the main body portion retracts.

Before continuing, it should be noted that the forwardmost staple in the main body portion 100, save for the staple which was ejected, was advanced by the leaf 127, immediately behind the leaf 126 of the leaf spring assembly 122 to a position beyond the leaf 128 of the leaf spring assembly 124. The reference numeral 112' shows the position of the forwardmost staple in the main body portion 100, save for the staple having been ejected, after the completed movement of the main body portion 100 in the direction of arrow 130. The arrow 132 is provided to indicate the movement of the secondmost forward staple in the main body portion 100 during the forward stroke of the main body portion.

After the forward stroke of the pusher 106, the forwardmost staple residing in the main body portion 100 is the staple 112'. After the knife and the pushers have retracted, the main body portion 100 begins to retract. At this occurrence, the first ramp 118 comes into contact with the cross-piece of the staple 112' while the second ramp 120 comes into contact with the forward arms of such staple. While the main body portion 100 is retracting, the staple 112 is held against the leaf 128 of the leaf spring assembly 124. Similarly, the remaining staples in the cartridge are held against respective leaves of the leaf spring assembly 124. With continued rearward movement of the main body portion 100, and with the forwardmost staple 112' held against the front face of the leaf 128, and being acted upon by the respective ramps 118 and 120, the staple 112 is caused to transfer, in the direction of arrow 134, from the index guide rail 114 to the ejection guide rail 116. Once the main body portion 100 has returned to its rearwardmost position, the individual elements of the assembly take the positions shown in FIG. 11. Then the cartridge is ready for the next stapling operation.

As noted previously, the forwardmost leaves 126 and 128 of the respective leaf spring assemblies 122 and 124 extend into the plane of the ejection guide rail 116 and thus extend into the plane of the pusher 106. For this reason, and as best seen in FIG. 10, the pushers 106 are notched at 136, in this way avoiding interference with the leaves of the respective leaf spring assemblies. And, as best seen in FIGS. 7, 10 and 11, the forward face of each pusher 106 is provided with sets of flats 138 serving to reduce the vertical diameter of the pushers with respect to the dimensions of the staples, thereby avoiding undesirable interference between the pushers and the tip of ramp 120.

With continuing reference to FIGS. 5 through 10, some additional features of the inventive cartridge will be described. As seen best in FIGS. 5, 8, 9 and 10, an ejector plate 140 is positioned intermediate the anvil assemblies 104. The ejector plate 140 functions to eject the organic tubular structure from

the jaws of the cartridge 12 after the completion of the suturing and dividing operations. During the forward motion of the main body portion 100, the ejector plate is carried with said main body portion and is moved out of the area of the anvil assemblies 104. Then, the pushers 106 and the knife 110 perform their respective functions and being to retract. When the main body portion 100 retracts, the ejector plate 140 is carried with said main body portion into the area of the anvil assemblies 104, as a result of the interaction between the rear portion of the knife and the rear portion of the ejector plate. In this manner, the surface of the ejector plate 140 facing the ligated and sutured tubular organic structure urges such structure out of the area of the anvil assemblies 104 and hence facilitates the expulsion of the divided tubular structure from the jaws of the cartridge. While not shown, the ejector plate 140 is limited in its movement with respect to the fixed rail assemblies 102. On the bottom of each rail assembly, there is provided a downwardly extending flange. And, surrounding each such flange is a slot provided in the bottom portion of the ejector plate. The width of the ejector plate slot is made slightly greater than the width of the downwardly projecting flange, thereby allowing slight relative movement between the rail assemblies, and hence the anvil assemblies, and the ejector plate.

As noted previously, certain elements of the inventive cartridge 12 are held fixed with respect to the main body portion 100 until acted upon by the associated surgical instrument. This is desirable for two distinct and important reasons. First, it is advantageous to maintain the rail assemblies, the main body portion, the pushers, and the knife in the respective positions facilitating insertion of the cartridge on the associated surgical instrument. And, second, it is necessary to prevent the pushers from accidentally ejecting a pair of staples from the cartridge and to prevent the knife from accidentally travelling forward in the cartridge before such cartridge is mounted on the associated instrument. Therefore, the inventive cartridge 12 is provided with means to releasably lock the knife, pusher and rail assemblies fixed with respect to said main body portion.

The knife 110 and pushers 106 are releasably locked with respect to the main body portion 100 as follows. On the upper surface of the knife 110, there is provided a notch 142. And, provided on the upper surface of the main body portion 100 is a detent 144. The detent 144 is resiliently biased into the plane of the notch 142 and is aligned therewith. Therefore, when the knife 110 is in its rearwardmost position, with the cartridge ready to be inserted on the associated surgical instrument, the detent 144 fits within the notch 142 and locks the knife 110 in position with respect to the main body portion 100. On the upper surface of the knife 110 is also provided an elongated depression 147. Adapted to slide within the depression 147 is the bridge 108 rigidly securing one pusher element 106 to the other. In this manner, when the knife 110 is locked in position with respect to the main body portion 100, so too are the pushers 106.

In a manner similar to that described above, the main body portion 100 is releasably locked in place with respect to the rail assemblies 102. A plastic spacer bar 146 is provided at the rear of the rail assemblies 102. And, at the forward portion of the spacer bar 146, there is provided a detent 148 resiliently biased into the plane of the bottom of the main body portion 100. A notch 150 is located in the main body portion 100 and is adapted to align with the detent 148 when the respective positions of the rail assemblies 102 and the main body portion 100 are suitable for insertion on an associated surgical instrument.

Above, there has been described a novel cartridge and instrument for ligating, suturing and dividing an organic tubular structure. It should be appreciated, however, that the above description is given for purposes of illustration only and that a number of modifications and alterations may be practiced by those skilled in the art without departing from the spirit or scope of the invention. It is the intent, therefore, that the in-

vention not be limited to the above but be limited only as defined in the appended claims.

What is claimed is:

1. A cartridge adapted for removeable insertion on a surgical instrument and having the capability of confining an organic tubular structure in a closed area within its jaws, encircling the structure with a pair of spaced apart surgical staples, suturing the structure with said surgical staples, and dividing the structure intermediate said surgical staples, the cartridge comprising: an elongated main body portion moveable relative to a rail assembly; a first pair of spaced apart guide tracks in said main body portion, each such guide track for guiding one staple of a plurality of serially spaced staple pairs along the length of said main body portion; a second pair of spaced apart guide tracks in said main body portion, each such guide track for singly guiding one staple of said plurality of staple pairs out of the region of said main body portion; the respective planes of each of said first pair of guide tracks being parallel to and spaced from the respective planes of each of said second pair of guide tracks for singly transferring said staple pairs from said first pair of guide tracks to said second pair of guide tracks; a third pair of guide tracks continuous with and in the plane of said second pair of guide tracks and extending external to said main body portion; a closeable opening in each of said third pair of guide tracks for the insertion of the organic tubular structure; a pair of curved anvil means continuous with and in the respective planes of said third pair of guide tracks; a pair of pusher elements in the respective planes of said second pair of guide tracks, each pusher element for singly advancing one staple of said plurality of staple pairs along one of said second guide tracks and one of said third guide tracks and for forming such staple on respective anvil means; knife means centrally mounted for movement in said main body portion intermediate the individual guide tracks and serving to divide said organic tubular structure; and means for transferring each of the staples of the forwardmost staple pair in said main body portion from the respective guide track of the first pair of guide tracks to the respective guide track of the second pair of guide tracks.

2. The cartridge recited in claim 1, wherein the means for transferring staples takes the form of a first set of staple-holding elements for maintaining the plurality of staples fixed with respect to said rail assembly during the movement of said main body portion away from said curved anvil means.

3. The cartridge recited in claim 2, and further comprising: a second set of staple-holding elements for maintaining the plurality of staples fixed with respect to said main body portion during the movement of said main body portion toward said curved anvil means.

4. The cartridge recited in claim 3, wherein said first set of staple-holding elements takes the form of a plurality of flexible members extending into the respective planes of said plurality of staples and adapted to contact said plurality of staples; and wherein the forwardmost members of said plurality of flexible members serve to shift the forwardmost staples from said first pair of guide tracks to said second pair of guide tracks.

5. The cartridge recited in claim 4, wherein said first and said second staple-holding elements are each in the form of leaf spring assemblies, the individual leaves of which are adapted to be moved out of the respective planes of said plurality of staples when the leaves of the other of said assemblies is maintaining the positions of said plurality of staples.

6. The cartridge recited in claim 4, wherein said first set of staple-holding elements is mounted on said respective rail assemblies; and wherein the second set of staple-holding elements is mounted on said main body portion.

7. The cartridge recited in claim 6, wherein the forwardmost element of each first staple-holding elements extends from the plane of the respective first guide track to the plane of the respective second guide track and is adapted to contact the respective forwardmost staple during its transition from said first guide track to said second guide track.

8. The cartridge recited in claim 4, wherein each of said pair of pusher elements is slotted so as to allow for the free passage of said pusher elements past said first and second staple-holding elements without contact therebetween.

9. The cartridge recited in claim 1, wherein said knife means is adapted to move in unison with said pair of pusher elements, lagging said pusher elements until a time when said pusher elements are in their fully forward positions in said main body portion.

10. The cartridge recited in claim 9, and further comprising means for ejecting the organic tubular structure after the ligating, suturing and dividing operations.

11. The cartridge recited in claim 10, wherein said ejector means is positioned intermediate said pair of anvil means and frictionally engages said main body portion.

12. The cartridge recited in claim 1, and further comprising means for releasably locking said knife means in said main body portion.

13. The cartridge recited in claim 12, wherein said knife locking means takes the form of a notch defined in said knife and a flexible detent defined in said main body portion adapted to align with and releasably lock in said notch.

14. The cartridge recited in claim 12, and further comprising means for releasably locking said pusher elements in said main body portion.

15. The cartridge recited in claim 14, wherein said respective pusher elements are joined together by a bridge; wherein said knife means is provided with a slot adapted to encompass and associate with said bridge; and wherein said pusher elements are restrained against movement in said main body portion by their association with said knife means.

16. The cartridge recited in claim 15, wherein said knife locking means takes the form of a notch defined in said knife and a flexible detent defined in said main body portion adapted to align with and releasably lock in said notch.

17. The cartridge recited in claim 1, and further comprising means for releasably locking said rail assembly in said main body portion.

18. The cartridge recited in claim 17, wherein said locking means takes the form of a notch defined in said main body portion adapted to align with said detent and a flexible detent defined in said rail assembly adapted to align with and releasably lock in said notch.

19. The cartridge recited in claim 1, wherein the respective rearwardmost portions of said main body portion, said pusher elements, said knife means and said rail assemblies, are staggered with respect to the forward end of said cartridge and are each provided with means for associating with a surgical instrument.

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