United States Patent

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[54] STAPLE CARTRIDGE WITH DRIVE BELT

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[52] **U.S. Cl.** **227/138**, 227/19, 227/136

[51] **Int. Cl.** **B25c 5/02**

[58] **Field of Search** 227/19, 113, 136, 137, 138

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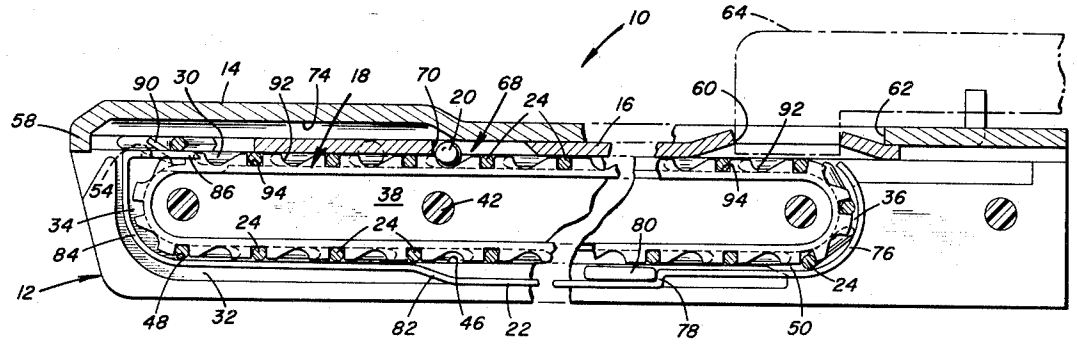
[57] **ABSTRACT**

A staple-housing cartridge suitable for use in a surgical arena, adapted to be mounted on a powering unit, and suitable for suturing the skin or fascia of a patient. A plurality of staples are guided and are driven by a continuous belt adapted for rotation in the cartridge housing. When the powering unit is activated, a pusher element integral with the cartridge ejects and form a staple and simultaneously advances the continuous belt, with its supply of staples, to ready the cartridge for the next stapling operation.

21 Claims, 7 Drawing Figures



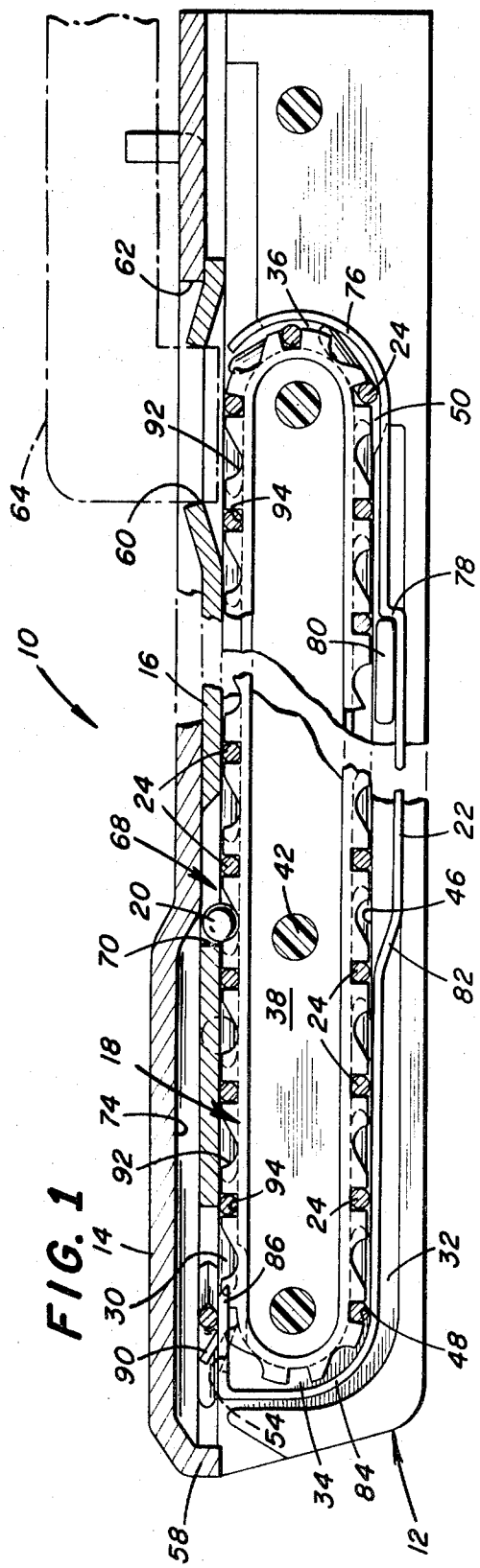

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FIG. 1

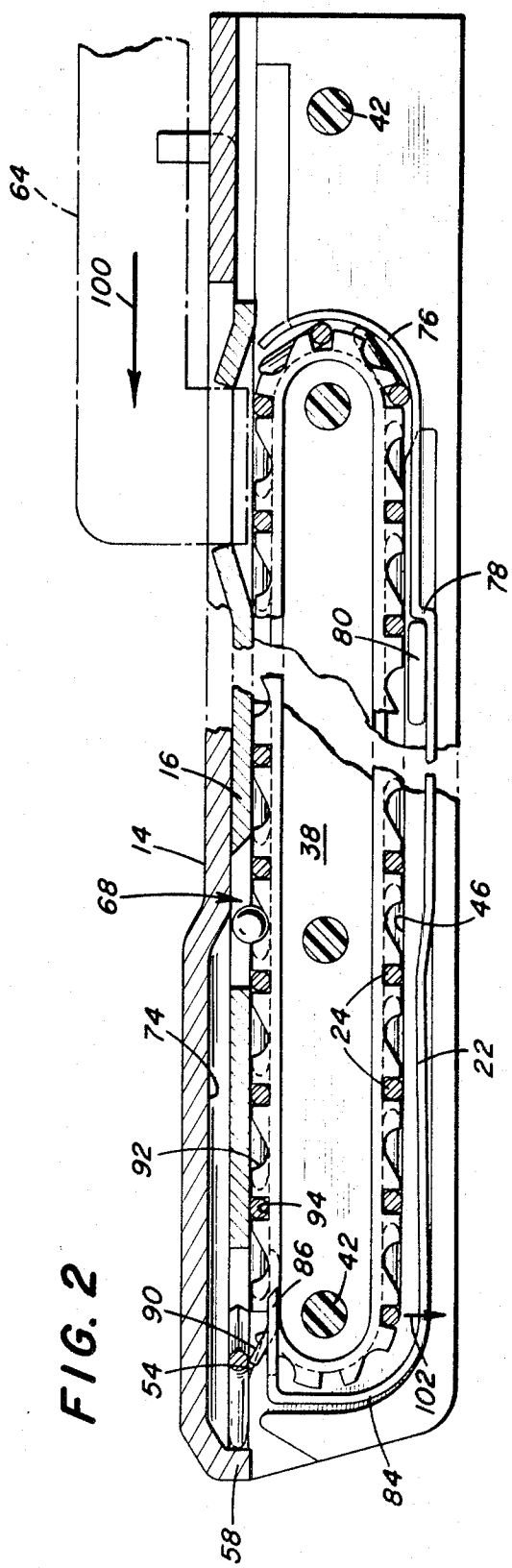
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FIG. 2

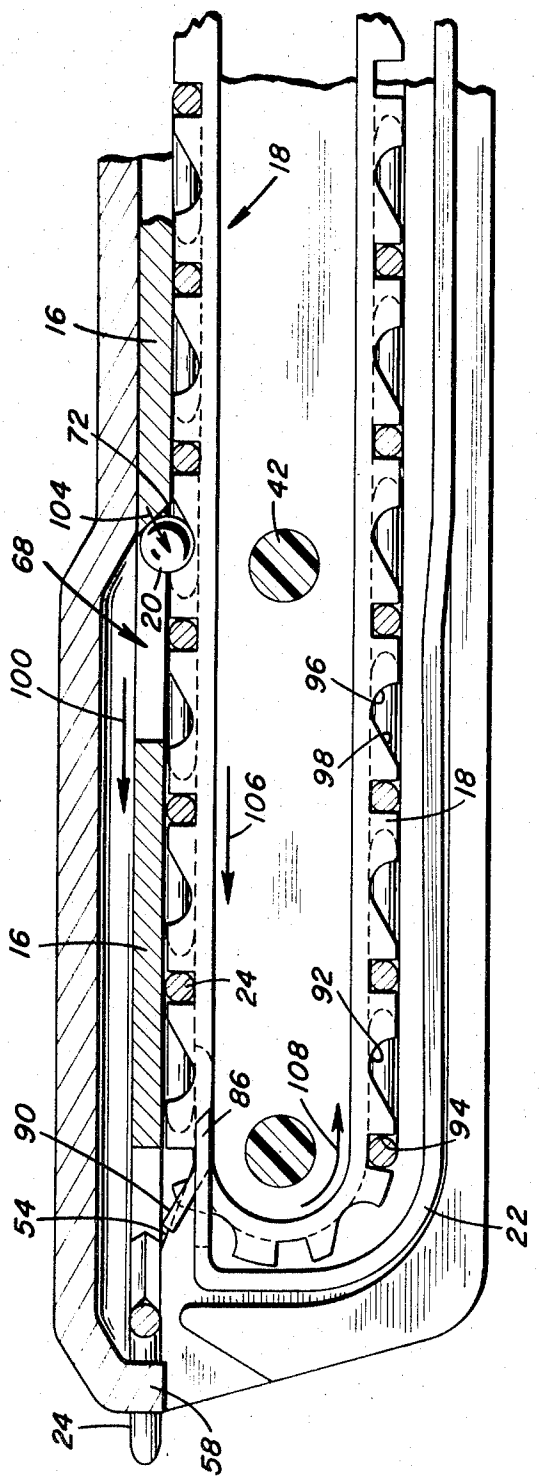
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FIG. 3

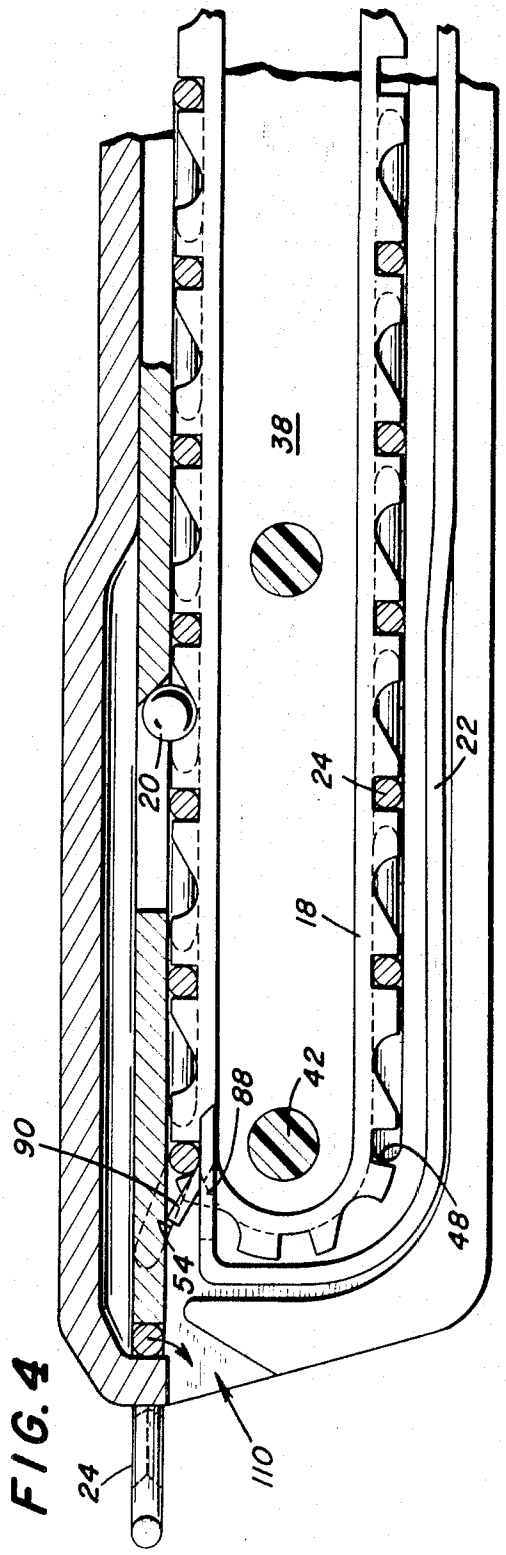
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FIG. 4

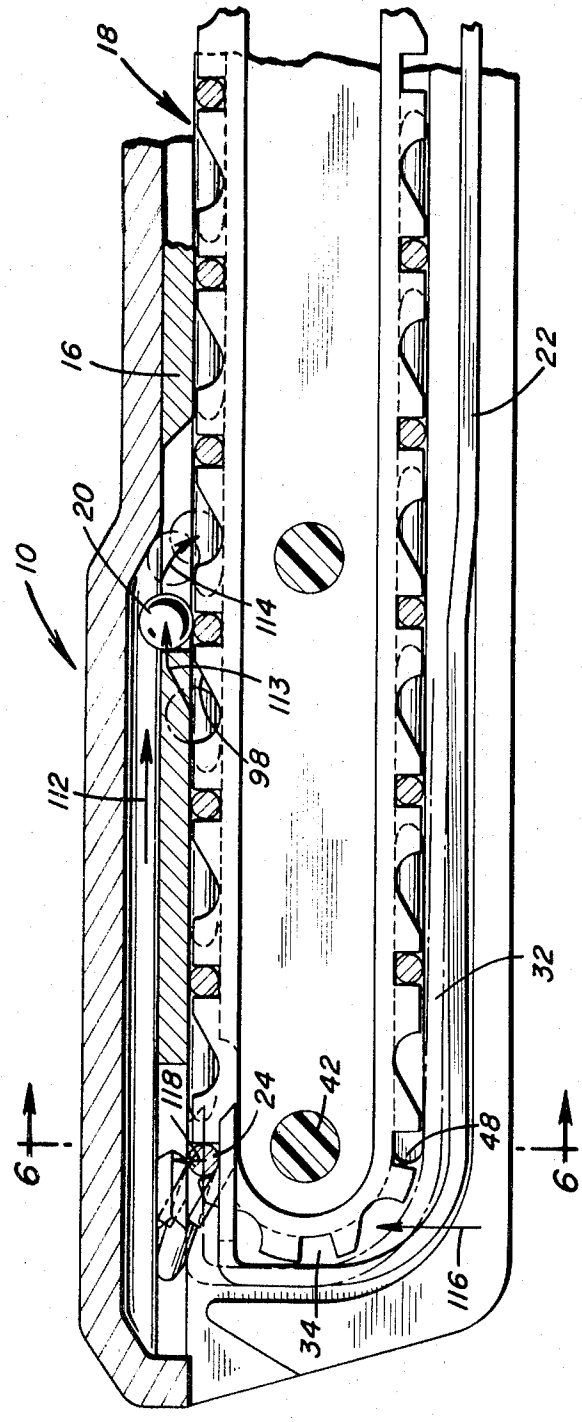

FIG. 5

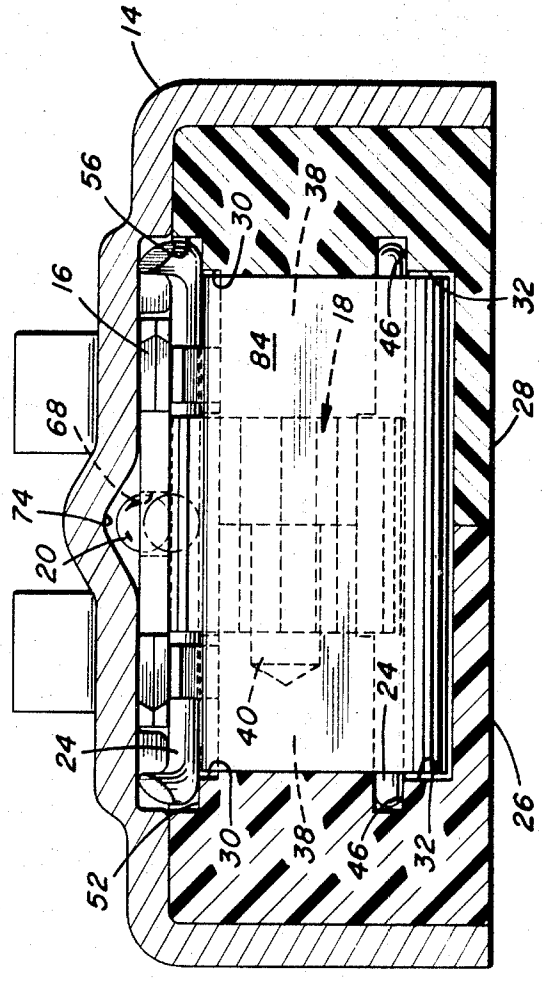

FIG. 6

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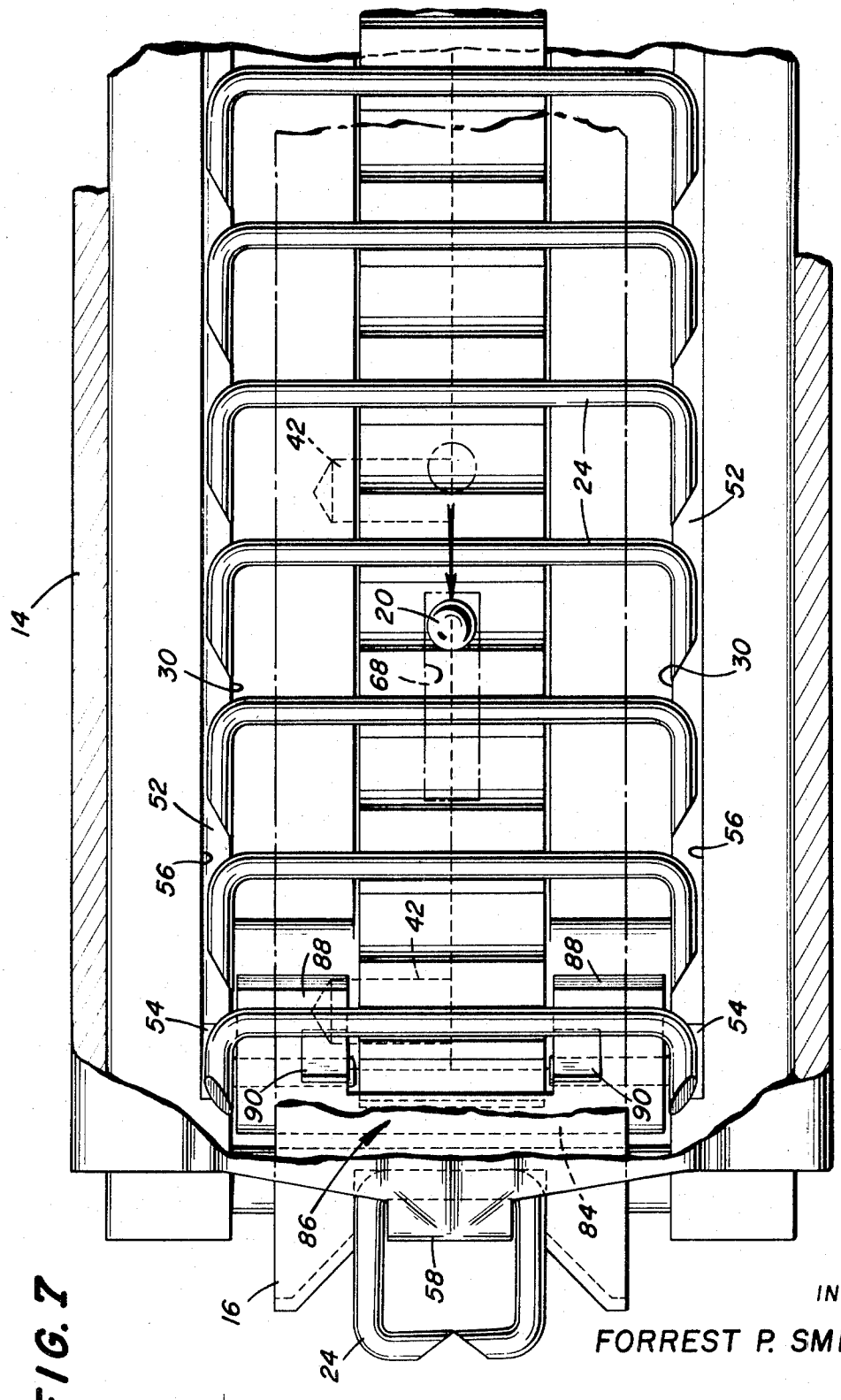

FIG. 7

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STAPLE CARTRIDGE WITH DRIVE BELT

BACKGROUND OF THE INVENTION

Recently, there has been considerable activity centered about the design of firing instruments and staple-housing cartridges for use in the surgical arena and adapted to staple together disjoined segments of skin or fascia. The basic principle of ejecting and forming a surgical staple in the skin or fascia of a patient is disclosed in copending U.S. Pat. application Ser. No. 852,822, assigned to the present assignee; and this basic principle has been carried through and is repeated in several other copending patent applications.

In the above-noted copending U.S. patent application, and in copending U.S. patent application Ser. No. 14,614, assigned to the present assignee, the staples housed in the respective cartridges are driven by helical screws which are, in turn, rotated by a complex gear box arrangement integral with the powering instrument.

More recently in the development of the skin and fascia stapler, cartridges have been designed which eliminate the requirement for the complex gearing once needed in the powering instrument. See, for example, copending U.S. patent applications Ser. No. 21,465 and Ser. No. 52,337, each assigned to the present assignee. In these latter-mentioned copending patent applications, the output shaft of the powering instrument need only have rectilinear thrust capabilities. The staples housed in the respective cartridges are driven forward by means designed into the cartridges themselves. In the first of these applications, the rectilinear motion developed by the powering instrument rotates a pair of staple-driving screws through the means of cams formed in the rear portions of the screws. In the second, the staples are driven forward by the interaction of pairs of opposing ratchet teeth.

Therefore, the basic principle of ejecting and forming a staple, as it was originally conceived, has been carried forward since its conception. However, as evidenced by the copending U.S. patent applications referenced above, continuous efforts have been made to improve the mechanism by which the staples are advanced in the cartridge.

While the medical stapling art has been greatly improved with the advent of the cartridges eliminating the need for complex staple advancing gears, there still remains room for improvement. The basic design of even the more recently developed cartridges is such that the length of the cartridge is directly proportional to the number of staples housed therein. That is, if it were desired to increase the staple-handling capacity of one of these cartridges by a factor of two, it would be necessary to substantially double the length of the cartridge. In addition, with each of the cartridges known to the prior art, the staples move relative to the staple advancing mechanism. Further, with each of these cartridges, the driving mechanism is used repeatedly. Therefore, there tend to be regions of concentrated wear in the prior art cartridges, regions which are potential areas of malfunction.

It is toward the elimination of the above-noted drawbacks in the prior art that the present invention is directed.

SUMMARY OF THE INVENTION

The present invention relates to a staple-housing cartridge provided with a flexible belt-like assembly for guiding and advancing the staples along the body of the cartridge. The cartridge is equipped with a pusher which acts directly on the belt-like assembly driving same and thereby advancing the plurality of staples with each forward thrust of the pusher. The pusher is adapted to associate with a powering instrument having only rectilinear thrust capabilities.

The belt-like assembly is provided with alternating staple-housing depressions and driving surfaces. The pusher associates, for example, with a ball and urges the ball into a respective driving surface with each forward thrust thereof. This brings about the advancement of the belt-like assembly and hence the advancement of each of the staples housed therein. With the rearward stroke of the pusher, the ball is urged out of its driving surface, over the next successive staple and into the next successive driving surface. At this time the cartridge is ready for another firing operation.

The driving ball contacts each driving surface only once. Hence, severe damage can occur to the driving surfaces without detrimentally affecting the future operation of the cartridge. And, because the belt-like assembly may be continuous, the staples may be housed entirely around the surface of the belt. In this manner, with each length of the staple cartridge, two lengths of staples may be provided. Accordingly, the number of staples which may be housed in the inventive cartridge is substantially doubled from the number of staples which may be housed in the cartridges known to the prior art.

Accordingly, it is a main object of the present invention to provide a simplified and reliable staple housing cartridge for joining the disunited skin and fascia of a patient.

It is another object of the present invention to provide a novel staple carrying cartridge having a plurality of staples guided and advanced by a flexible belt-like assembly.

Yet a further object of the present invention is to provide a novel staple carrying cartridge housing a plurality of staples which are advanced in response to rectilinear motion originating in a power unit.

Yet another object of the present invention is to provide a novel staple carrying cartridge whose driving mechanism operates on portions of the flexible belt only once.

A further object of the present invention is to provide a relatively small staple carrying cartridge having the capability of carrying a large number of staples therein.

Yet a further object of the present invention is to provide a novel staple carrying cartridge capable of housing staples in two spaced planes in the body of said cartridge.

Yet another object of the present invention is to provide a staple carrying cartridge wherein a plurality of staples are guided and advanced by means of a continuous belt.

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.

GRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross section through a staple-housing cartridge designed in accordance with the present invention, when in its pre-firing condition;

FIG. **2** is a cross section similar to FIG. **1** but showing the cartridge during the early stages of the firing operation;

FIG. **3** is an enlarged cross section of the front portion of the inventive cartridge, when near the end of the firing operation;

FIG. **4** is a cross section similar to FIG. **3**, showing the inventive cartridge at the end of the firing operation;

FIG. **5** is a cross section similar to FIG. **3**, showing the inventive cartridge during the return stroke;

FIG. **6** is a cross section taken along line **6—6** of FIG. **5**; and

FIG. **7** is a top view of the portion of the cartridge illustrated in FIG. **4**.

DETAILED DESCRIPTION OF THE DRAWINGS

With reference first to FIGS. **1**, **6** and **7**, the construction of the inventive staple-housing cartridge will be described. The cartridge is shown generally at **10** and comprises a main body portion **12**, a cover **14**, a staple pusher **16**, a continuous belt drive **18**, a driving ball **20** and a biasing spring **22**. A plurality of staples **24** are shown housed in the cartridge.

As seen in FIGS. **1** and **6**, the main body portion **12** is of two-piece construction and is defined by respective body halves **26** and **28**. A continuous deep groove is defined in each half, forming an upper belt space **30**, a lower belt space **32**, a forward belt space **34** and a rear belt space **36**. The central region of each body half enclosed by the belt spaces is shown at **38** and may be termed a belt guiding surface. The belt guiding surface **38** in the body half **26** is provided with a plurality of

bores 40 which are adapted to mate with an equal number of mating pins 42 provided in the belt guiding surface 38 of body half 28. Preferably, the pins 42 are integral with the body half 28 which is conveniently molded of plastic.

In each of the respective body halves 26 and 28, adjacent the lower belt space 32 and the rear belt space 36, is a shallow groove defining a staple guide space 46. As seen in FIGS. 1 and 5, the guide space 46 begins at wall 48 near the forward end of the cartridge 10 and continues linearly until reaching the rear of the cartridge. When in the area of the rear belt space 36, the staple guide space widens, as shown at 50, and follows the shape of the rear belt space 36. The widened area 50, as shown in FIG. 1, allows the advancing staples to move from the bottom of the cartridge 10 to the top thereof without binding.

Near the top of each body half, and adjacent the upper belt space 30, is defined a ledge 52. The ledge 52 extends from the rear of the cartridge 10, where it meets with the widened portion 50 of the staple guide space 46, to the forward end of the cartridge. At the forward end of the cartridge, the ledge 52 terminates in a ramp portion 54 shown, for example, in FIGS. 1 and 7. As can best be seen in FIGS. 6 and 7, each ledge 52 and its associated ramp 54 is bordered by a wall 56, the spacing between respective walls 56 being slightly greater than the width of a staple 24.

With reference now to FIGS. 1, 6 and 7, the configuration of the pusher 16 will be described. The basic design of the pusher 16 remains substantially unchanged from the pushers described in each of the above-noted copending U.S. patent applications. The end of the pusher 16 is U-shaped, has a chamfer on each of the arms thereof, and, acting with the anvil 58 on the cover 14, is adapted to mate with the drive shaft 64 of the associated powering instrument. The pusher in the inventive cartridge differs from the prior pushers in that an elongated slot 68 is cut through the front ends of the pusher, positioned along the longitudinal axis thereof. The forward end 70 of the slot 68 is defined by a wall cut transverse to the body of the pusher, while the rear wall 72 of the slot 68 is defined by a wall cut at an angle with respect to the body thereof.

The driving ball 20, as seen in FIGS. 1, 6 and 7, rides within the groove 68 in the pusher 16 and is maintained along the longitudinal axis of the cartridge 10 by the combined effects of the slot 68 and an elongated internal depression 74 defined in the cover 14. As will be explained below, the ball 20, when acted upon by the pusher 16, drives the belt 18 and thus advances the staples 24 in the body of the cartridge 10.

With reference now to FIGS. 1, 6 and 7, the configuration of the biasing spring 22 will be described. The spring 22 is elongated and is of a length which approximates the length of the lower belt space 32. The rear portion of the biasing spring 22, shown at 76, is curved and conforms to the shape of the outer wall of the rear belt space 36. Near the rear of the cartridge 10, the spring 22 takes a sharp bend 78 allowing the spring to pass under a restraining tab 80 which is preferably molded with the respective body halves. Near the forward end of the cartridge 10, the spring 22 is smoothly bent at 82.

The forward end 84 of the biasing spring 22 curves upwardly and conforms to the shape of the forward belt space 34. Near the upper region of the forward end 84, the spring 22 abruptly bends and takes a U-shape as shown at 86 in FIGS. 1 and 7. The U-shaped region 86 of the spring 22 comprises a pair of arms 88 which are spaced apart a distance slightly in excess of the width of the continuous belt 18. A tab 90, extending upwardly and toward the front of the cartridge 10, extends from each of the arms 88.

For reasons which will become clear from the following, the smooth bend 82 in the spring 22 is of such a configuration as to bias the U-shaped region 86 of the spring 22 toward the cover 14, this biasing maintaining the region of the spring between the sharp bend 78 and the smooth bend 82 in contact with the bottom wall of the lower belt space 32. And, as seen when comparing FIGS. 1 and 2, the belt spaces 32 and 34 are dimensioned so as to allow the forward end of the biasing spring 22 to move, against its biasing force, to a position wherein it contacts the belt guiding surface 38.

As noted previously, the belt 18 is continuous, and, as best seen in FIGS. 1 and 3, has defined therein a plurality of spaced driving surfaces shown generally at 92, and a plurality of spaced staple guiding grooves 94. Each driving surface 92 comprises a cylindrical forward wall 96 and a sloping rearward wall 98. For reasons which will be explained below, the cylindrical forward wall 96 is adapted to mate with the driving ball 20 for controlling the movement of the belt 18 in response to the action of the driving ball. And, for reasons which will also be explained below, the sloping rearward wall 98 serves as a ramp over which the driving ball 20 may ride when the cartridge 10 is being readied for a staple driving and advancing operation.

The cartridge 10 is constructed as follows. With the body halves 26 and 28 apart, the biasing spring 22 is inserted under the restraining tab 80. Then, the continuous belt 18 is positioned over one of the belt driving surfaces 38. With the biasing spring 22 and the continuous belt 18 in place, the body halves 26 and 28 are united, the pins 42 being mated with the bores 40. The staples 24 are then loaded, either manually or mechanically, in their respective guiding grooves 94. Conveniently, the staples are inserted, one at a time, in the rearwardmost exposed groove. After each insertion, the belt is moved in a clockwise direction with respect to FIG. 1 until the first staple inserted contacts the wall 48 terminating the staple guide space 46. Then, each of the exposed grooves on the top of the continuous belt 18 are loaded with staples, and the pusher 16 and the driving ball 20 are positioned above the belt 18. The pusher is forced against the belt 18 so that the forwardmost staple takes the position shown in solid lines in FIGS. 5 and 6, and the cover 14 is snapped into place. Then the pusher 16 is retracted. The fully loaded cartridge 10 is shown in FIG. 1.

The cartridge is sterilized, is packaged in a sealed container, and is shipped to its use site. Then the cartridge is removed and inserted on its associated firing instrument, as described in the first of the above-noted copending patent applications. In FIG. 1, the fully loaded cartridge is shown as it would be associated with a firing unit, the pusher 16 being in its fully retracted position and mating with the drive shaft 64 of the firing instrument.

Now, the operation of the inventive cartridge will be described. As seen in FIG. 1, the forwardmost staple 24 in the fully loaded cartridge is held against the cover 14 through the action of the biasing spring 22, and is held in its track between the upstanding tabs 90 and the forward end of the pusher 16. The driving member 64 of the powering instrument is associated with the pusher 16 and the cartridge is ready to be fired.

Upon activation of the powering instrument, and as shown in FIG. 2, the drive shaft 64 moves in the direction of arrow 100. The interaction between the drive shaft 64 and the pusher 16 results in the pusher moving in the direction of arrow 100. The forward end of the pusher 16 contacts the forwardmost staple 24 and moves this staple toward the anvil 58 on the cover 16. The driving ball 20, with the continuous belt 18, are unaffected by the initial movement of the pusher 16, the slot 68 moving with respect to but not contacting the driving ball 20.

With the pusher 16 and the forwardmost staple 24 in the respective positions shown in FIG. 2, the biasing spring 22 is cammed in the direction of arrow 102. This camming action is the result of the interaction between the crossbar of staple 24 and the upstanding tabs 90 on the spring 22. With continued forward motion of the pusher 20, the biasing spring 22 remains in the position shown in FIG. 2, the tabs 90 then being cammed by the pusher body itself.

The forward movement of the pusher 16 and the forwardmost staple 24 continues as described in the preceding paragraph until the angled wall 72 of the slot 68 contacts the driving ball 20. This instant of initial contact is illustrated in FIG.

3. With continued movement of the pusher **16** in the direction of arrow **100**, the angled wall **72** exerts a force on the driving ball **20** in the direction of arrow **104**. This force drives the ball **20** against the cylindrical forward wall **96** of the driving surface **92** and causes movement of the belt **18**. That is, the downward component of the force indicated by arrow **104** holds the ball **20** against the driving surface **92** while the horizontal component of the force indicated by arrow **104** drives the belt **18** in the direction of the arrow **106**. With belt movement in the direction of arrow **106**, the forward region of the belt moves around the belt guiding surface **38** as shown at **108**. At the same time, the pusher **16** moves the forwardmost staple **24** toward the anvil **58**. The biasing spring **22**, as noted previously, is held against the guiding surface **38**.

The action described in the preceding paragraph continues until the pusher has completed its formation of the staple **24** around the anvil **56**, as shown in FIGS. **4** and **7**. It will be noted that with the cartridge elements in the positions shown in FIG. **4**, the belt **18** has been advanced a distance so that the arms of the forwardmost staple **24** have traveled up the ramp **54** and so that the crossbar of the forwardmost staple is located above the arms **88** of the biasing spring U-shaped region **86**. Still, the pusher **16** is in contact with the tabs **90** and maintains the biasing spring **22** against the guiding surface. At the end of the stapling operation, illustrated in FIG. **4**, the formed and ejected staple **24** is able to slide through opening **110** once the pusher **16** has begun to retract.

FIG. **5** illustrates the relative positions of the cartridge elements during the return stroke of the pusher **16**. The initial movements of the pusher **16** in the direction of arrow **112** has no effect on the ball **20** or the belt **18**. However, when the face **70** of the pusher slot **68** contacts the ball **20**, during the rearward movement of the pusher, the ball **20** rides up the sloping rearward wall **98** of the driving surface **92** and continues in the direction of arrow **113**, to ride over the next adjacent staple **24** until the driving ball **20** contacts the rear surface of the internal depression **74**. Then, the combined effects of the face **70** of the pusher slot **68** and the sloping rear wall of the internal depression **74** seats the ball **20** in the next successive driving surface **92**. The ball enters the region of the surface **92** after overcoming the resistive force offered by the resilient belt **18**. The sequence of movement of the driving ball **20** is illustrated in FIG. **5** by successive phantom and solid representations.

With continued reference to FIG. **5**, the attention of the reader is directed to the forward region of the cartridge **10**. As noted previously, the biasing spring **22** is held in its downwardmost position by the pusher **16** when the pusher is in the forward region of the cartridge **10**. As also noted previously, at the beginning of the pusher retraction, the forwardmost staple **24** is aligned with and sits above the arms **88** of the U-shaped region **86** of the biasing spring **22**. This is illustrated in solid lines in FIG. **5**. When, however, the pusher **16** moves in the direction of arrow **112** so that the tabs **50** on the arms **88** are free from the effects of the pusher, the forward region of the biasing spring **22** moves in the direction of arrow **116** as a result of its upward bias. At this occurrence, the forwardmost staple **24** is urged upwardly in the cartridge **10**, in the direction of arrow **118**, and takes the position illustrated in FIG. **1**. Then, once the pusher **16** has returned to its rearwardmost position, the cartridge **10** is ready for the next firing operation.

The simplicity and the effectiveness of the inventive staple-housing and driving cartridge should be appreciated from the above. The number of parts defining the inventive cartridge is small and, accordingly, the compounding of manufacturing inaccuracies is avoided to a large extent, and the manufacturing costs are low. Also, the inventive staple-housing cartridge is capable of carrying a large number of staples in a relatively compact volume; this is important when one remembers that the inventive cartridge is disposable. Because the staple is the least expensive element in the cartridge, the inventive cartridge has a per-staple cost substantially less than the cartridges known to the prior art. The inventive cartridge has additional major advantages. Each staple is housed in and remains in its own staple groove until it is ready for expulsion. This is unlike those cartridges already known to the prior art wherein a plurality of staples advance over the same staple-housing regions. Therefore, staple control in the inventive cartridge is more positive than has heretofore been possible. Further, the driving ball of the inventive cartridge encounters each driving surface only once. Therefore, it is possible to damage the driving surfaces after initial contact with the driving ball, without jeopardizing the operation of the cartridge. In contrast to this, the driving of the prior art cartridges takes place at the same region until the staples are exhausted. Therefore, damage to the prior art driving mechanism could conceivably result in costly cartridge malfunction.

Above, a specific embodiment of the present invention has been described. It should be appreciated, however, that this embodiment is described for purposes of illustration only and that numerous alterations and modifications may be practiced by those skilled in the art without departing from the spirit and scope of the invention. Accordingly, it is the intent that the invention not be limited by the above but be limited only as defined in the appended claims.

What is claimed is:

1. A cartridge for housing a plurality of surgical staples, which is adapted to be mounted on a powering instrument, and which is capable of joining the disunited skin or fascia of a patient with surgical staples, the cartridge comprising: an elongated main cartridge body; cover means for maintaining the integrity of the cartridge elements and including an anvil means; a belt movably mounted in the longitudinal direction of the main body; a plurality of staple receiving grooves evenly spaced about said belt; a plurality of driving surface means spaced about said belt; driving means for engaging said driving surfaces and for controlling movement of said belt; means responsive to rectilinear motion in said powering instrument for activating said driving means; and pusher means for singly ejecting and bending said plurality of staples from said main cartridge body and bending same on said anvil means.

2. The cartridge recited in claim **1**, wherein said driving surface means comprises a plurality of driving surfaces in said belt and respectively positioned intermediate each pair of adjacent staple grooves.

3. The cartridge recited in claim **2**, wherein said driving means is adapted to singly engage said driving surfaces, to move said melt in response to the forward movement of said powering instrument, and to move to the next successive driving surface in response to the rearward movement of said powering instrument.

4. The cartridge recited in claim **3**, wherein said driving means is a ball.

5. The cartridge defined in claim **4**, wherein said means for activating said driving means is a slot defined in said pusher means.

6. The cartridge recited in claim **5**, wherein said slot has a forward face transverse to the plane of said pusher means and a rearward face sloped with respect to the plane of said pusher means.

7. The cartridge recited in claim **6**, wherein the slope of said rearward face maintains said driving means in contact with a respective driving surface to cause movement of said belt during the forward motion of said pusher.

8. The cartridge recited in claim **1**, and further comprising: biasing spring means for singly removing the forwardmost staple from its staple groove and for biasing the removed staple into the plane of said pusher means.

9. The cartridge recited in claim **8**, and further comprising: tab means integral with said biasing spring for moving said biasing spring means out of the plane of said staple grooves during the movement of said belt.

10. The cartridge recited in claim **9**, wherein said tab means is cammed by the crossbar of the forwardmost staple and by the pusher when said staple and said pusher are, respectively, in the forward region of said cartridge.

11. The cartridge recited in claim 10, wherein said biasing spring means is biased into the plane of said pusher.

12. The cartridge recited in claim 1, and further comprising: ledge means defined in said elongated main cartridge body, said ledge means extending in the plane of said staple grooves in the upper region of said cartridge for receiving the legs of the staples carried in said staple receiving grooves.

13. The cartridge recited in claim 12, wherein said ledge means terminates, at the forward end of said cartridge, in a ramp serving to move the legs of the forwardmost staple out of the plane of said staple grooves and into the plane of said pusher.

14. The cartridge recited in claim 13, and further comprising: biasing spring means for urging the crossbar of the forwardmost staple out of the plane of said staple grooves and into the plane of said pusher.

15. The cartridge recited in claim 14, and further comprising: a staple guiding space defined in the lower region of said elongated main cartridge body, said staple guiding space being in the plane of said staple grooves and communicating with said ledge means through a curved staple guiding path.

16. The cartridge recited in claim 15, wherein said ledge means, said staple guiding space and said curved staple guiding path are continuous so that staples may be positioned in said staple grooves substantially around the entire periphery of said belt.

17. The cartridge recited in claim 1, wherein said driving surface means takes the form of a plurality of driving surfaces spaced about the periphery of said belt and positioned intermediate each pair of said staple grooves; each driving surface comprising a cylindrical forward wall and a sloped rearward wall; wherein said driving means has a curved surface to mate with said cylindrical forward wall; and wherein said means for activating said driving means takes the form of a slot in said pusher means.

18. The cartridge recited in claim 17, wherein the forward wall of said pusher slot is perpendicular to the plane of said pusher and wherein the rearward wall of said pusher slot is angled with respect to the plane of said pusher, the angle of said rearward wall being such that when said angled wall contacts said driving means, said driving means is maintained in contact with said cylindrical forward wall of said driving surface and causes movement of said belt.

19. The cartridge recited in claim 18, and further comprising: biasing spring means for urging the forwardmost staple out of the plane of said staple grooves and into the plane of said pusher.

20. The cartridge recited in claim 19, and further comprising: tab means integral with said biasing spring for contacting said forwardmost staple and said pusher means, respectively, for urging said biasing spring out of the plane of said grooves during movement of said belt.

21. The cartridge recited in claim 1, wherein said belt is a continuous belt.

* * * * *