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(54) LAPAROSCOPIC BIPOLAR ELECTROSURGICAL INSTRUMENT

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(51) **Int. Cl.**^{7} **A61B 18/14**

(52) **U.S. Cl.** **606/50**; 606/46; 606/48; 606/207; 606/208

(58) **Field of Search** 606/46, 48–52, 606/170, 207, 208

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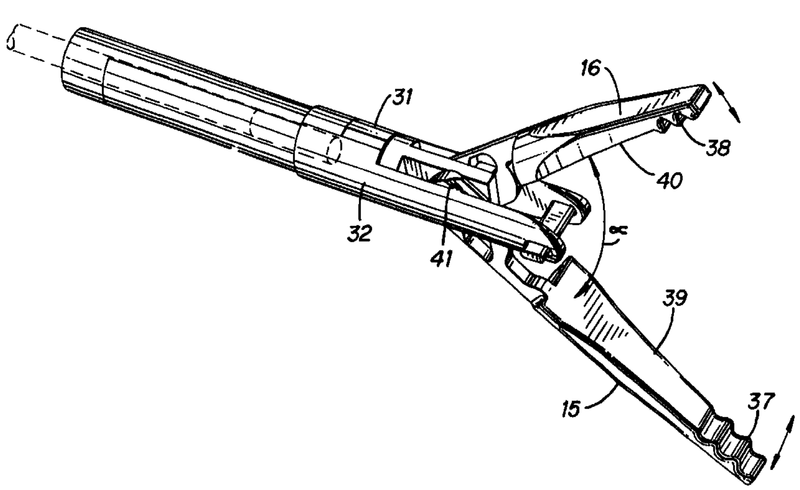
Primary Examiner—Lee Cohen

(57) **ABSTRACT**

A laparoscopic bipolar electrosurgical instrument can apply a large closure force between its jaws without damaging the small yoke assembly. The instrument comprises: a first jaw having a first flange with a first slot, and a second jaw having a second flange with a second slot, wherein the first and second jaws are located at a distal end of the instrument and comprise an electrically conductive material for conducting bipolar electrosurgical current therebetween; a yoke attached to a pushrod and positioned to electrically insulate the first flange from the second flange, the yoke having a first side facing the first flange and a second side facing the second flange, the yoke further comprising a first shoulder and a second shoulder; a first pin located on the first side and movably engaged with the first slot; a second pin located on the second side and movably engaged with the second slot; the first slot and the second slot shaped such that an angle, subtended by the first and second jaws, decreases with distal motion of the pushrod, and first and second cul-de-sacs positioned respectively in the first and second slots to relieve shear stresses on the first and second pins approximately when the first and second shoulders respectively engage the first and second flanges to provide a closure force between the first and second jaws.

8 Claims, 5 Drawing Sheets



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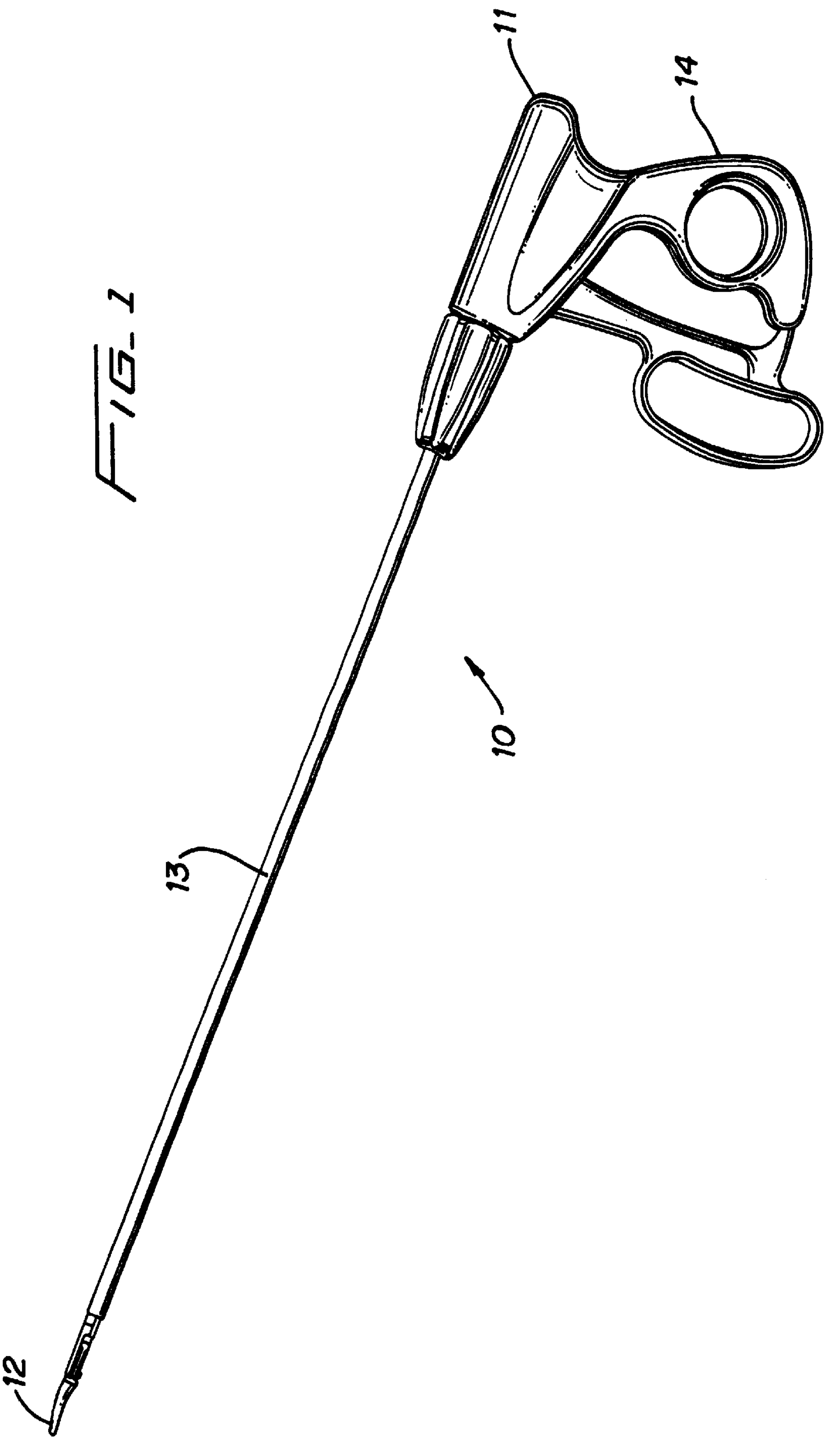


FIG. 1

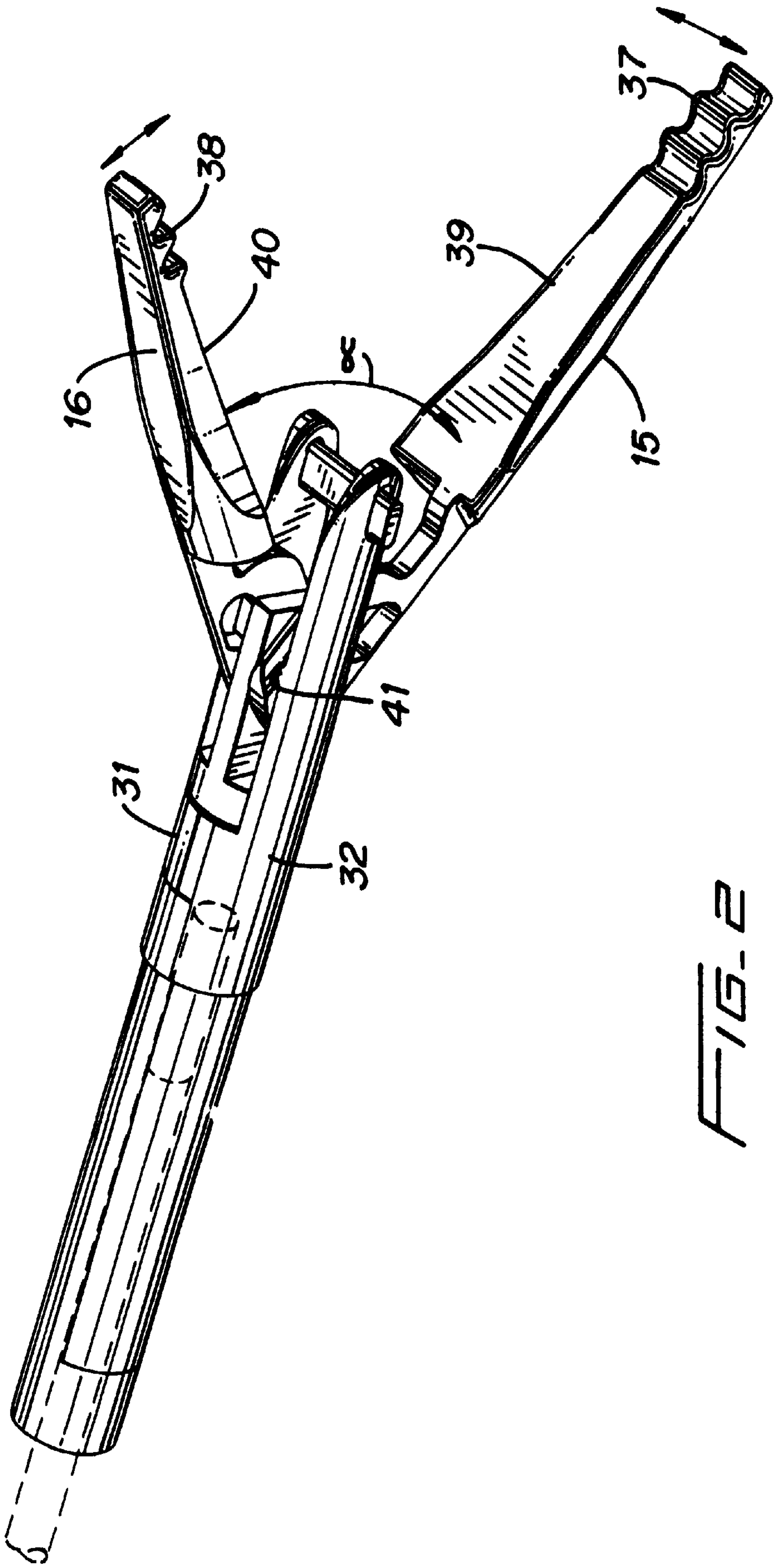


FIG. 2

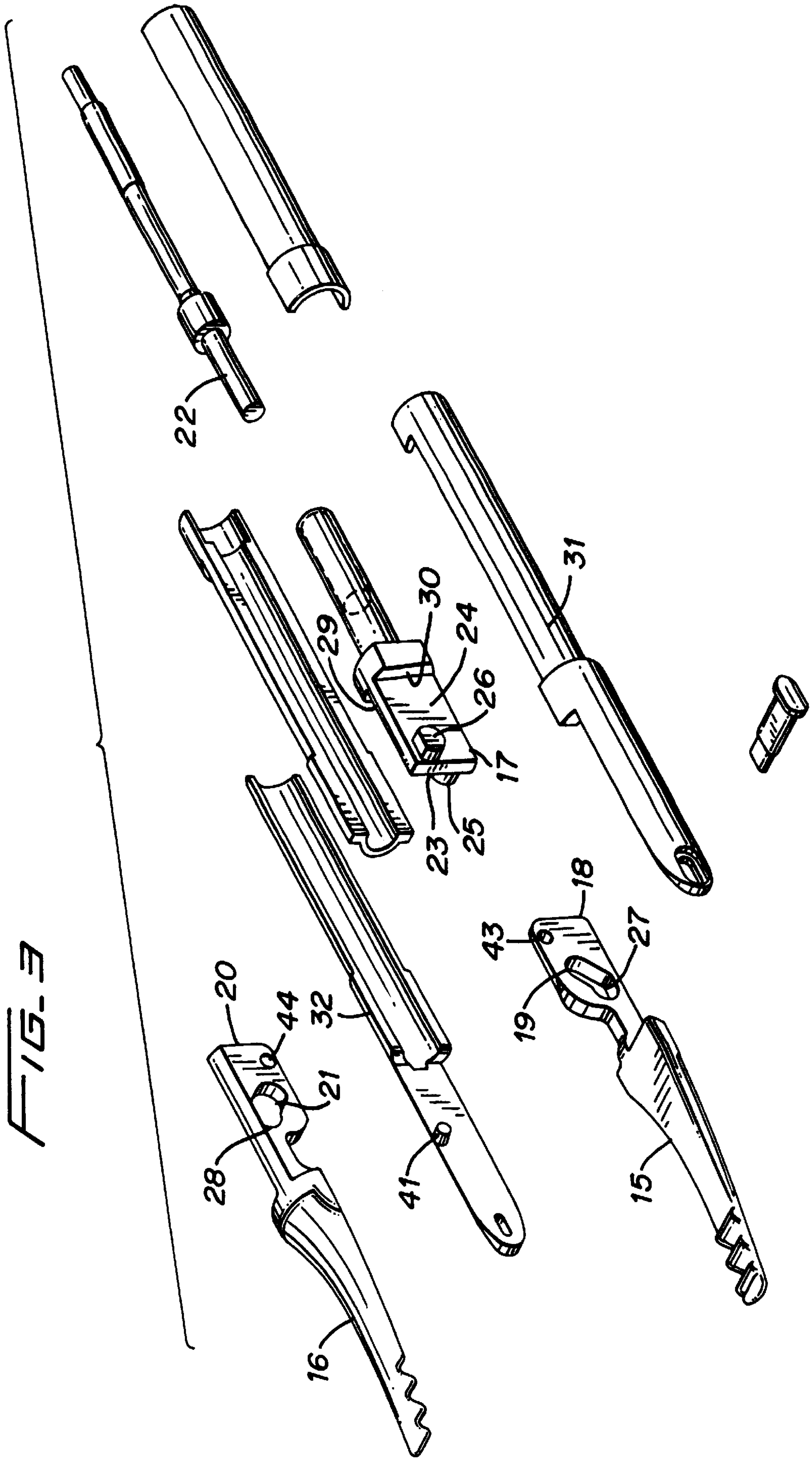


FIG. 3

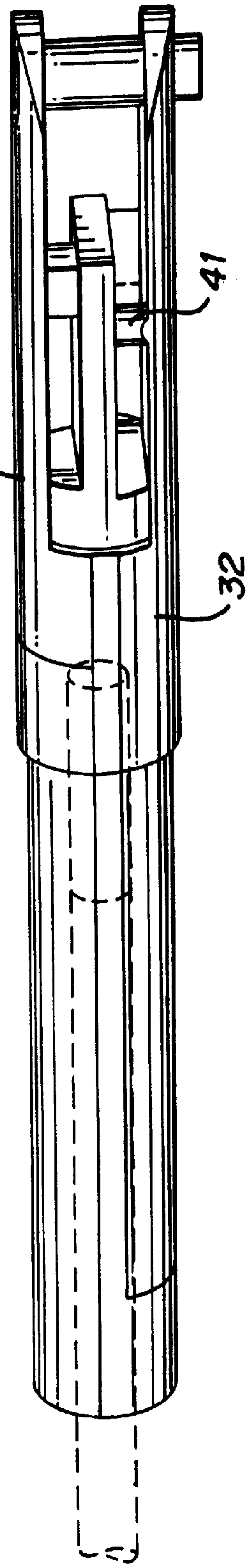


FIG. 4

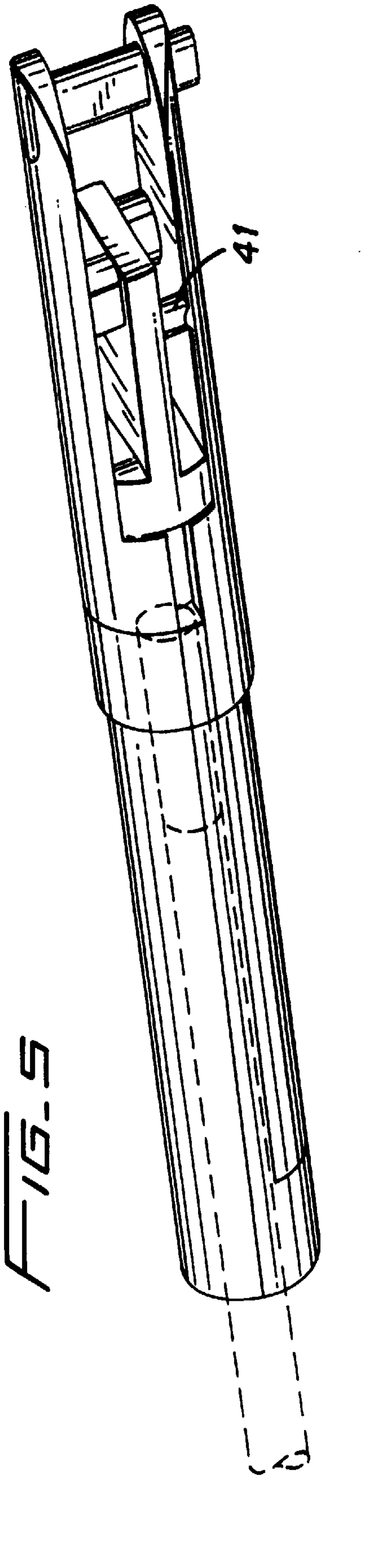


FIG. 5

FIG. 6

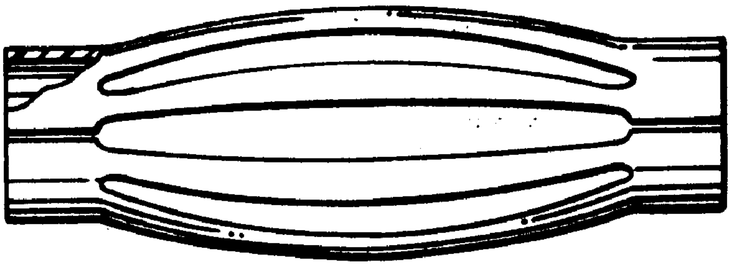
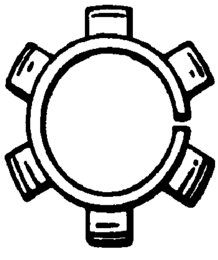


FIG. 7



LAPAROSCOPIC BIPOLAR ELECTROSURGICAL INSTRUMENT

This application is a continuation of U.S. application Ser. No. 08/970,472 filed on Nov. 14, 1997, now U.S. Pat. No. 6,228,083.

FIELD OF THE INVENTION

This relates to an electrosurgical instrument for performing laparoscopic surgical procedures, and more particularly to a laparoscopic electrosurgical instrument that is capable of grasping vessels and vascular tissue with sufficient force between two bipolar jaws to seal the vessel or vascular tissue.

BACKGROUND OF THE DISCLOSURE

Laparoscopic surgical instruments are used to perform surgical operation without making large incisions in the patient. The laparoscopic instruments are inserted into the patient through a cannula, or port, that has been made with a trocar. Typical sizes for cannulas range from three millimeters to twelve millimeters. Smaller cannulas are usually preferred, and this presents a design challenge to instrument manufacturers who must find ways to make surgical instruments that fit through the cannulas.

Certain surgical procedures require cutting blood vessels or vascular tissue. This sometimes presents a problem for surgeons because it is difficult to suture blood vessels using laparoscopic tools. Very small blood vessels, in the range below two millimeters in diameter, can often be closed using standard electrosurgical techniques. If a larger vessel is severed, it may be necessary for the surgeon to convert the laparoscopic procedure into an open-surgical procedure and thereby abandon the benefits of laparoscopy.

Several journal articles have disclosed methods for sealing small blood vessels using electrosurgery. An article entitled *Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator*, J. Neurosurg., Volume 75, Jul. 1991, describes a bipolar coagulator which is used to seal small blood vessels. The article states that it was not possible to safely coagulate arteries with a diameter larger than 2 to 2.5 mm. A second article is entitled *Automatically Controlled Bipolar Electrocoagulation—"COA-COMP"*, Neurosurg. Rev. (1984), pp. 187–190. This article describes a method for terminating electrosurgical power to the vessel so that charring of the vessel walls can be avoided.

It has been recently determined that electrosurgical methods may be able to seal larger vessels using an appropriate electrosurgical power curve, coupled with an instrument capable of applying a large closure force to the vessel walls. It is thought that the process of coagulating small vessels is fundamentally different than electrosurgical vessel sealing. Coagulation is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dried. Vessel sealing is defined as the process of liquefying the collagen in the tissue so that it crosslinks and reforms into a fused mass. Thus, coagulation of small vessels is sufficient to permanently close them. Larger vessels need to be sealed to assure permanent closure.

It would be desirable to have a surgical tool capable of applying electrosurgical energy, capable of applying a large closure force to the vessel walls, and also capable of fitting through a cannula. A large closure force between the jaws typically requires a large moment about the pivot for each jaw. This presents a challenge because the first and second pins have a small moment arm with respect to the pivot of each jaw. A large force, coupled with a small moment arm, is undesirable because the large forces may shear the first and second pins. It is also undesirable to increase the moment arm of the first and second pins because the physical size of the yoke might not fit through a cannula.

Several bipolar laparoscopic instruments are known. For example, U.S. Pat. No. 3,938,527 discloses a bipolar laparoscopic instrument for tubal cauterization. U.S. Pat. No. 5,250,047 discloses a bipolar laparoscopic instrument with a replaceable electrode tip assembly. U.S. Pat. No. 5,445,638 discloses a bipolar coagulation and cutting forceps with first and second conductors extending from the distal end. U.S. Pat. No. 5,391,166 discloses a bipolar endoscopic instrument having a detachable working end. U.S. Pat. No. 5,342,359 discloses a bipolar coagulation device.

The present invention solves the problem of providing a large closure force between the jaws of a laparoscopic bipolar electrosurgical instrument, using a compact design that fits through a cannula, without risking structural failure of the instrument yoke.

SUMMARY OF THE INVENTION

The present invention is an instrument for applying bipolar electrosurgical current to tissue in a laparoscopic operation with the added benefit of providing a large closure force between the instrument jaws. The large closure force may be particularly useful for vessel sealing operations. An advantage of the present invention is that tissue can be grasped and clamped with a relatively large closure force without damage to the yoke. The yoke is capable of transmitting the large closure force to the instrument jaws while being small enough to fit through a cannula The laparoscopic bipolar electrosurgical instrument comprises first and second jaws having, respectively, first and second flanges with first and second slots. The instrument is electrically connected to an electrosurgical generator, and conducts bipolar electrosurgical current to the first and second jaws. A yoke is attached to a pushrod and positioned to electrically insulate the first flange from the second flange. First and second pins on the yoke are designed to engage the first and second slots, respectively, in a cam-follower arrangement that opens and closes the jaws with linear motion of the yoke. The yoke is preferably a "push yoke" which means that linear motion of the yoke in the direction of the distal end of the instrument will cause the jaws to close together.

The yoke has first and second shoulders that are spaced apart from the first and second flanges until the jaws are in close arcuate proximity to each other. At that point, the first and second shoulders engage the first and second flanges, whereby further distal motion of the yoke applies a force to the first and second flanges that creates a moment about the pivot of each jaw. In general, the cam-follower arrangement of pins and slots may be designed to provide coarse motion of the jaws with relatively small forces. Large closure forces, once the jaws are relatively close together, may be obtained by pressing the shoulders against the flanges. The first and second pins move into cul-de-sacs in the first and second slots to protect them from large shear stresses when the shoulders are applying relatively large forces to the flanges. Thus, the first and second pins may be made from an electrically insulative material that is not designed to handle large shear stresses, large closure forces may be obtained, and the entire assembly may be compact and fit through a cannula

A method of making the laparoscopic bipolar electrosurgical instrument is described, comprising the following steps: forming a first jaw having a first flange with a first slot, and a second jaw having a second flange with a second slot; attaching a yoke to a pushrod; electrically insulating the first flange from the second flange with the yoke; engaging first and second pins with the first and second slots; positioning first and second cul-de-sacs respectively in the first and second slots to relieve shear stresses on the first and second pins at a subtended angle approximately wherein first and second shoulders engage the first and second flanges.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a laparoscopic bipolar electrosurgical instrument.

FIG. **2** is a perspective view of the distal end and jaws of the instrument in FIG. **1**.

FIG. **3** is an exploded view of the distal end shown in FIG. **2**.

FIG. **4** is perspective view of the distal end of the instrument with the jaws removed.

FIG. **5** is another perspective of FIG. **4**.

FIG. **6** is a side views of an electrical spring contact.

FIG. **7** is a front view of the spring contact shown in FIG. **6**.

DETAILED DESCRIPTION OF THE INVENTION

A laparoscopic bipolar electrosurgical instrument **10** is shown in FIG. **1**. The instrument **10** has a proximal end **11** with a handle **14** for holding and manipulating the instrument **10**. A distal end **12** on the instrument **10** is used for surgical manipulation of tissue. The instrument **10** comprises an elongate tube **13** that is sized to fit through a cannula for laparoscopic operations, and in different embodiments may be sized to fit through either a five or seven millimeter cannula.

A portion of the distal end **12** of the instrument **10** is shown in FIG. **2**. A first jaw **15** and a second jaw **16** are shown in an open position. An angle a is subtended by the jaws **15** and **16**. Closing of the jaws **15** and **16** is defined as a reduction of the angle a subtended by the jaws **15** and **16**. Similarly, opening of the jaws **15** and **16** is defined as an enlargement of the angle a. The angle a is zero when the jaws **15** and **16** are closed together. The center of rotation for the first jaws **15** is at the first pivot **41**, and the center of rotation for the second jaw **16** is at the second pivot **42**. The first pivot **41** is located on an outer nose piece **32**, and fits in a first pivot hole **43** located on the first flange **18**. The second pivot **42** is located on an inner nose piece **31**, and fits in a second pivot hole **44** located on the second flange **20**.

Pieces that comprise the distal end **12** of the instrument **10** are shown in an exploded view in FIG. **3**. The first jaw **15** and the second jaw **16** are shown separated from a yoke **17**. The first jaw **15** has a first flange **18** and a first slot **19** therewithin. The second jaw **16** has a second flange **20** and a second slot **21** therewithin. Each jaw **15** and **16** is preferably formed from a single piece of stainless steel or other electrically conductive material.

Referring again to FIG. **3**, the yoke **17** is attached to a pushrod **22**. The yoke **17** is preferably formed from an electrically insulative material such as plastic. A first side **23** of the yoke **17** faces the first flange **18**. A second side **24** of the yoke **17** faces the second flange **20**. When the yoke **17** is positioned between the flanges **18** and **20**, the yoke **17** also acts to electrically insulate the first jaw **15** from the second jaw **16**. In this manner, bipolar electrosurgical current can be conducted through tissue grasped by the jaws **15** and **16** without short circuiting between the flanges **18** and **20**.

A first pin **25** is located on the first side **23** to movably engage with the first slot **19**. Similarly, a second pin **26** is located on the second side **24** to movably engage with the second slot **21**. Each pin and slot combination works as a cam-follower mechanical linkage. Motion of the pushrod **22** moves the yoke **17** causing pins **25** and **26** to slide within their respective slots **19** and **21**. The slots **19** and **21** are angled with respect to the distal ends of the jaws **15** and **16** such that the jaws **15** and **16** move in an arcuate fashion toward and away from each other. The pins **25** and **26** are different from the pivots **41** and **42**. The pins **25** and **26** provide a force against the walls of the slots **19** and **21**, creating a moment about the pivots **41** and **42**.

The slots **19** and **21** are arranged such that distal motion of the pushrod **22** causes the jaws **15** and **16** to move together. Distal motion of the pushrod **22** is defined as motion in the direction of the distal end **12** of the instrument **10**. Once thejaws **15** and **16** are closed together, the present invention holds the jaws **15** and **16** together with a compressive force on the pushrod **22**.

One of the advantages of this invention is that shear forces on the pins **25** and **26** can be offloaded to prevent mechanical failure when large forces are being transmitted to the jaws **15** and **16**. Each slot **19** and **20** has a cul-de-sac **27** and **28**, respectively, as shown in FIG. **3**. The first cul-de-sac **27** is an enlargement of the first slot **19** near its distal end. The second cul-de-sac **28** is an enlargement of the second slot **21** near its distal end. The cam-follower motion of the pins **25** and **26** in the slots **19** and **21** will bring the pins **25** and **26** into their respective cul-de-sac **27** and **28**. This position of the pins **25** and **26** leaves a very small moment arm between the pins **25** and **26** and the pivots **41** and **42**. The yoke **17** has shoulders **29** and **30** that can provide a relatively large moment about the pivots **41** and **42** to effect a high closure force between the jaws **15** and **16** without a high shear forces on the pins **25** and **26**, as described below.

Once the pins **25** and **26** are in the cul-de-sacs **27** and **28**, the force from the yoke is transmitted to the flanges **18** and **20** by a first shoulder **29** and a second shoulder **30**. The shoulders **29** and **30** abut the proximal end of the flanges **18** and **20** to cause the jaws **15** and **16** to close together. The pivots **41** and **42** are preferably made of metal and can withstand relatively high shear forces. In contrast, pins **25** and **26** are preferably made of plastic and will break under relatively high shear forces. Thus, the shoulders **29** and **30** provide a moment lo about the pivots **41** and **42**, thereby avoiding the necessity of applying high shear forces to the pins **25** and **26** when the moment arm from the pins **25** and **26** would be small. There is an angle a at which the pins **25** and **26** enter their respective cul-de-sacs **27** and **28** and the shoulders **29** and **30** abut the flanges **18** and **20**. The angle α at which the forgoing occurs is preferably around three degrees.

The bipolar electrosurgical instrument **10** has first and second poles of alternating potential that are conducted along the instrument **10** and through tissue that is grasped between the jaws **15** and **16**. The first pole is conducted from the proximal end **11** toward the distal end **12** along the pushrod **22**. The second pole is conducted from the proximal end **11** toward the distal end **12** along the tube **13**. The outer surface of the tube **13** is preferably coated with an electrically insulative material. There is also preferably an electrically insulative barrier between the pushrod **22** and the tube **13** to prevent short circuits in the instrument **10**.

In the preferred embodiment, the distal end of the instrument **10** comprises an inner nose piece **31** and an outer nose piece **32**, as shown in FIG. **2**. The inner nose piece **3 1** is electrically connected with the pushrod **22**, while the outer nose piece is electrically connected with the tube **13**. The inner nose piece **31** and the outer nose piece **32** capture the yoke **17**, along with the first and second flanges **18** and **20**, as shown in FIG. **2**. The yoke **17** moves axially, along an axis defined by the tube, in a space between the inner and outer nose pieces **31** and **32**. A spacer stake **33** maintains the separation of the nose pieces **31** and **32** at their distal ends. The nose pieces **31** and **32** provide lateral support for the flanges **18** and **20** to help ensure that the pins **25** and **26** remain within the slots **19** and **21**. The preferred embodiment also comprises an inner insulator **34** and an outer insulator **35** for maintaining electrical insulation between the poles. The outer insulator **35** is seated between the tube **13** and the inner nose **31**, as shown in FIGS. **2** and **4**. The inner insulator **34** is seated between the tube **13** and the pushrod **22**. In this manner, the outer nose piece **32** can provide electrical continuity between the tube **13** and the second jaw **16**, while the inner nose piece **34** can provide electrical continuity between the pushrod **22** and the first jaw **15**. Since the pushrod Z " is slidably mounted within the tube **13**, the preferred embodiment has a spring contact **36**, as shown in FIGS. **6** and **7**, mounted on the pushrod **22** to maintain an electrical connection with the inner nose piece **34** during axial motion.

The first and second jaws **15** and **16** each have ridges **37** and **38** at their distal ends that preferably nest together. The jaws **15** and **16** also have seal surfaces **39** and **40**, as shown in FIG. **2**. The width of the seal surfaces **39** and **40** is a parameter that affects the quality of the surgical outcome. The closure force between the jaws **15** and **16** varies along the length of the seal surfaces **39** and **40**, with the largest force at the distal tip and the smallest force at the proximal end of the seal surfaces **39** and **40**. It has been found through experimentation that good vessel sealing results are obtained when the closure force in grams divided by the width in millimeters is in the range of 400 to 650. Since the closure force varies with the length of the seal surfaces **39** and **40**, it has been found to be advantageous to taper the width of the seal surfaces **39** and **40** along their length, with the widest width at the proximal end and the narrowest width at the distal end. This design allows the jaws **15** and **16** to apply a relatively constant closure force per unit width, preferably 525 grams per millimeter width.

A method of making a laparoscopic bipolar electrosurgical instrument **10** is also herein described. The method comprises the step of forming a first jaw **15** having a first flange **18** with a first slot **19**, and a second jaw **16** having a second flange **20** with a second slot **21**. The jaws **15** and **16** are preferably formed in a casting process, although it is also possible to machine the jaws **15** and **16** from stock. The casting process may include injecting powdered metal under pressure into a mold, and then applying heat.

Other steps in the method include attaching a yoke **17** to a pushrod **22**, and electrically insulating the first flange **18** from the second flange **20** with the yoke **17**. The yoke **17** is preferably an injection molded plastic part with features including a first shoulder **29** and a second shoulder **30**.

During assembly of the distal portion of the instrument **10**, steps in the method include engaging a first pin **5** with the first slot **19**, and engaging a second pin **26** with the second slot **21**. The slots **19** and **21** are shaped such that a subtended angle a between the first and second jaws **15** and **16** decreases with distal motion of the pushrod **17**, and the slots **19** and **20** are formed with cul-de-sacs **27** and **28** positioned to relieve shear stresses on the first and second pins **25** and **26** at the subtended angle α approximately wherein the first and second shoulders **29** and **30** engage the first and second flanges **18** and **20**.

Further steps in the method comprise: surrounding at least a portion of the pushrod **22** with an electrically conductive tube **13**; electrically insulating the tube **13** from the pushrod **22**; electrically connecting an inner nose piece **31** to the pushrod **22**, and electrically connecting an outer nose piece **32** to the tube **13**, wherein the inner nose piece **31** and the outer nose piece **32** capture the yoke **17** along with the first and second flanges **18** and **20** to conduct bipolar electrosurgical current to the first and second jaws **15** and **16**. In the preferred embodiment, there is a step of electrically connecting the pushrod **22** and the inner nose piece **31** with a spring contact **36**.

The method of making the instrument **10**, in some embodiments, includes the steps of tapering the width of the seal surfaces **39** and **40** along the length of each of the first and second jaws **15** and **16**.

While a particular preferred embodiment has been illustrated and described, the scope of protection sought is in the claims that follow.

What is claimed is:

1. A laparoscopic bipolar endoscopic instrument, comprising:

first and second jaw members, one of the jaw members being movable relative to the other of the jaw members from a first open position wherein the jaw members are disposed in spaced relation relative to one another to a second clamping position wherein the jaw members cooperate to grasp tissue therebetween,

an electrically conductive push rod for connecting the first jaw member to a first electrical potential and an electrically conductive tube for connecting the second jaw member to a second electrical potential such that the jaw members are capable of conducting bipolar energy through the tissue held therebetween;

a yoke having at least one pin attached thereto which slidably engages the law members, the yoke being movable such that the pin imparts movement of the jaw members from the first and second positions;

a pair of shoulder portions attached to the yoke which are configured to abut the jaw members when the jaw members are moved into the second position to relieve shear stress on the pin during clamping and sealing of the tissue; and

a handle which cooperates with the push rod for imparting movement to the yoke.

2. The laparoscopic bipolar electrosurgical instrument of claim **1** wherein the electrically conductive tube surrounds at least a portion of the pushrod, and an electrically insulative layer is disposed between the tube and the pushrod capable of supporting an electrosurgical alternating potential across the tube and the pushrod.

3. The laparoscopic bipolar electrosurgical instrument of claim **2** further comprising:

an inner nose piece electrically connected to the pushrod, and

an outer nose piece electrically connected to the tube, wherein the inner nose piece and the outer nose piece capture the yoke to conduct bipolar electrosurgical current to the first and second jaw members.

4. The laparoscopic bipolar electrosurgical instrument of claim **3** further comprising an electrical spring contact between the pushrod and the inner nose piece to provide electrical continuity therebetween.

5. The laparoscopic bipolar electrosurgical instrument of claim **1** further comprising ridges in each of the first and second jaw members.

6. The laparoscopic bipolar electrosurgical instrument of claim **1** wherein each of the first and second jaw members has a seal surface with width and a length, and wherein at least one location along the length has a width such that the closure force in grams divided by the width in millimeters is in the range of 400 to 650.

7. The laparoscopic bipolar electrosurgical instrument of claim **6** wherein the width of at least one of the seal surfaces is tapered along its respective length.

8. The laparoscopic bipolar electrosurgical instrument of claim **7** wherein the closure force in grams divided by the width in millimeters is approximately constant along the length for each of the first and second jaw members.

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专利名称(译)	腹腔镜双极电外科仪器		
公开(公告)号	US6451018	公开(公告)日	2002-09-17
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[标]申请(专利权)人(译)	舍伍德服务股份公司		
申请(专利权)人(译)	SHERWOOD SERVICES AG		
当前申请(专利权)人(译)	COVIDIEN AG		
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摘要(译)

腹腔镜双极电外科器械可在其钳口之间施加大的闭合力而不损坏小轭组件。该器械包括：第一钳口，具有带有第一槽的第一凸缘;以及第二钳口，具有带有第二槽的第二凸缘，其中第一和第二钳口位于器械的远端并包括导电材料用于在其间传导双极电外科电流;轭连接到推杆并且定位成使第一凸缘与第二凸缘电绝缘，轭具有面向第一凸缘的第一侧和面向第二凸缘的第二侧，轭还包括第一肩部和第二肩部;第一销位于第一侧并可移动地与第一槽接合;第二销位于第二侧并可移动地与第二槽接合;第一狭槽和第二狭槽成形为使得第一和第二钳口对向的角度随着推杆的远侧运动而减小，并且第一和第二穹顶分别定位在第一和第二狭槽中以减轻剪切应力大致当第一和第二肩部分别接合第一和第二凸缘时，在第一和第二销上，以在第一和第二夹爪之间提供闭合力。