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(54) **RIGIDLY-LINKED ARTICULATING WRIST WITH DECOUPLED MOTION TRANSMISSION**

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See application file for complete search history.

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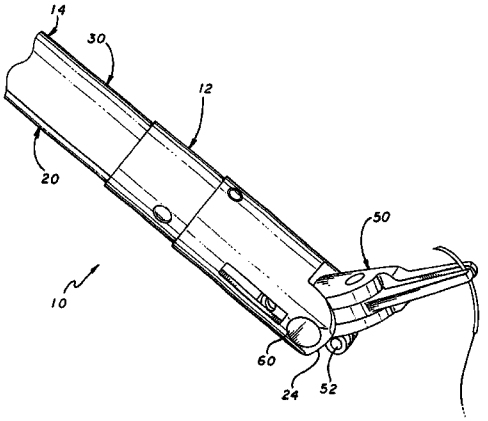
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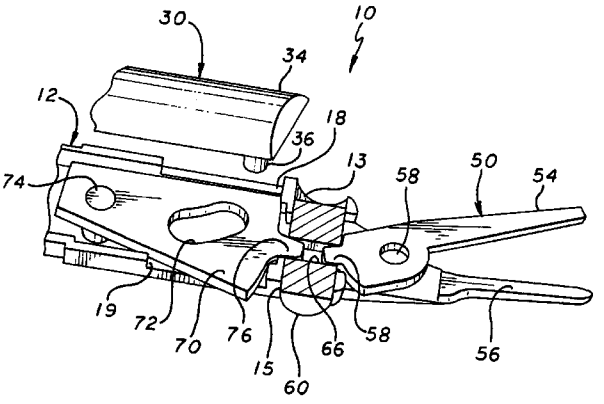
Primary Examiner — Victor Nguyen

(57) **ABSTRACT**

The present invention is a device having a rigidly linked jaw that is decoupled from an articulating wrist. The device provides for articulating motion as well as actuation that may be used in grasping, cutting, suturing or the like.

1 Claim, 3 Drawing Sheets





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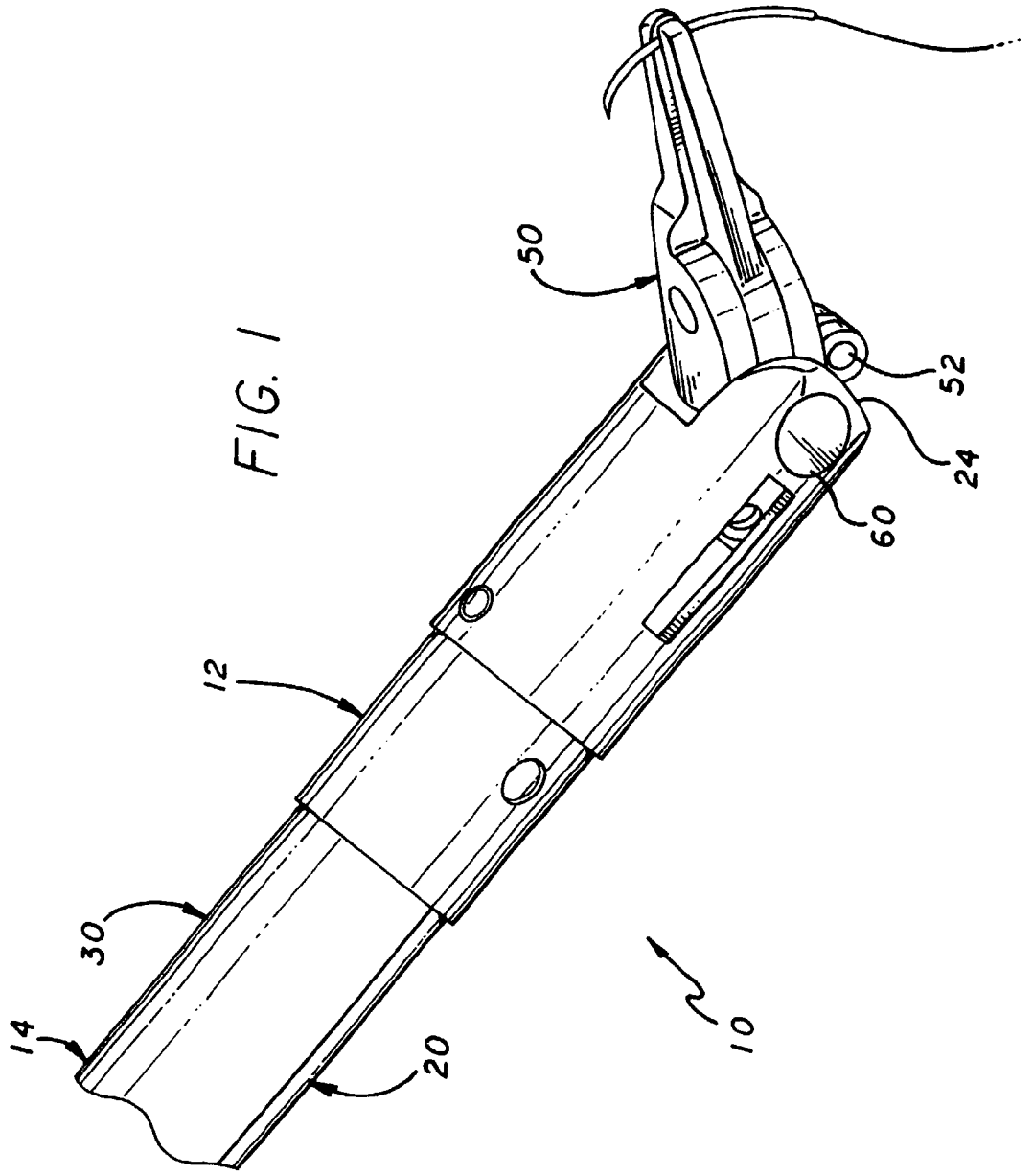


FIG. 1

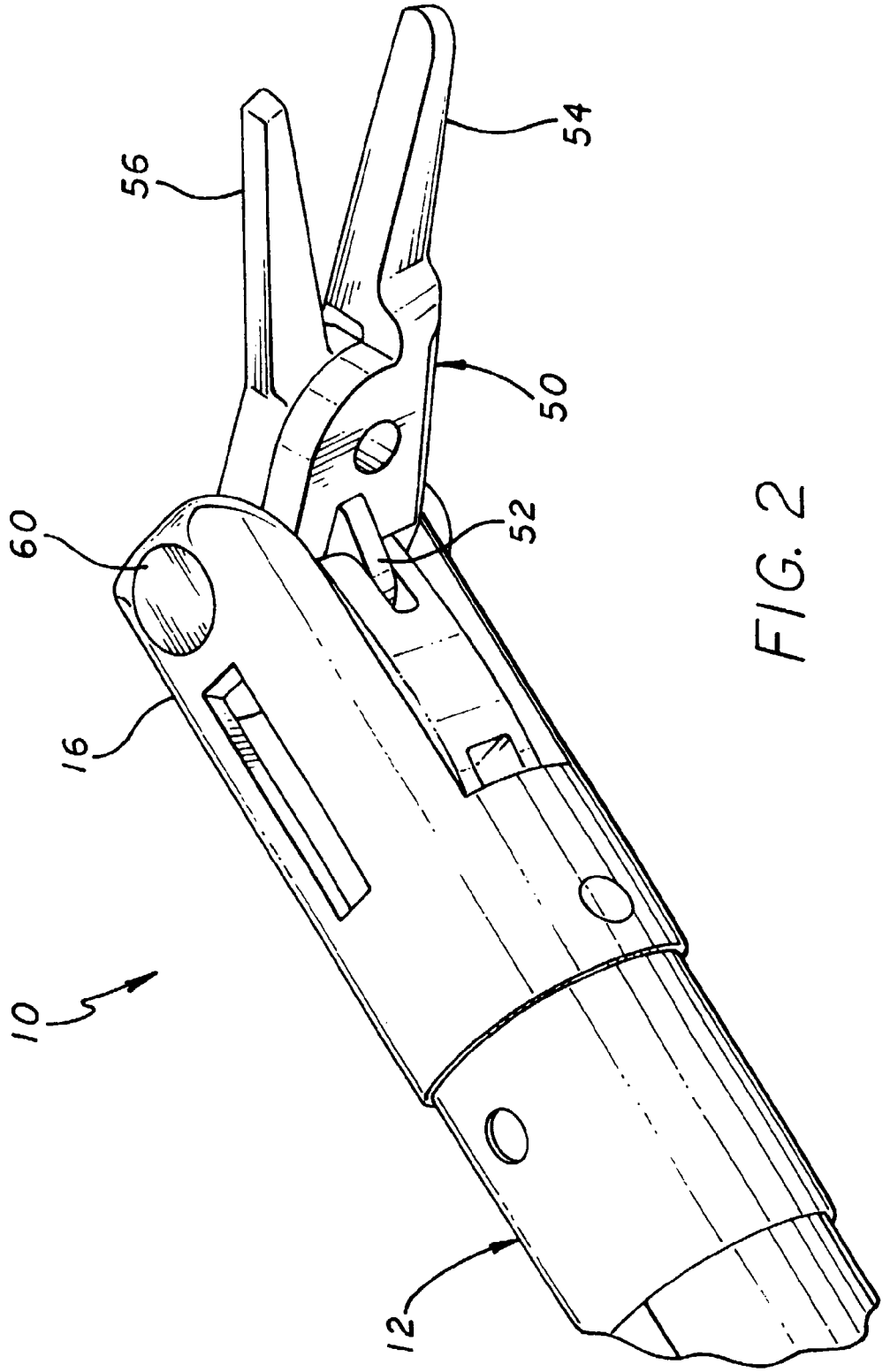
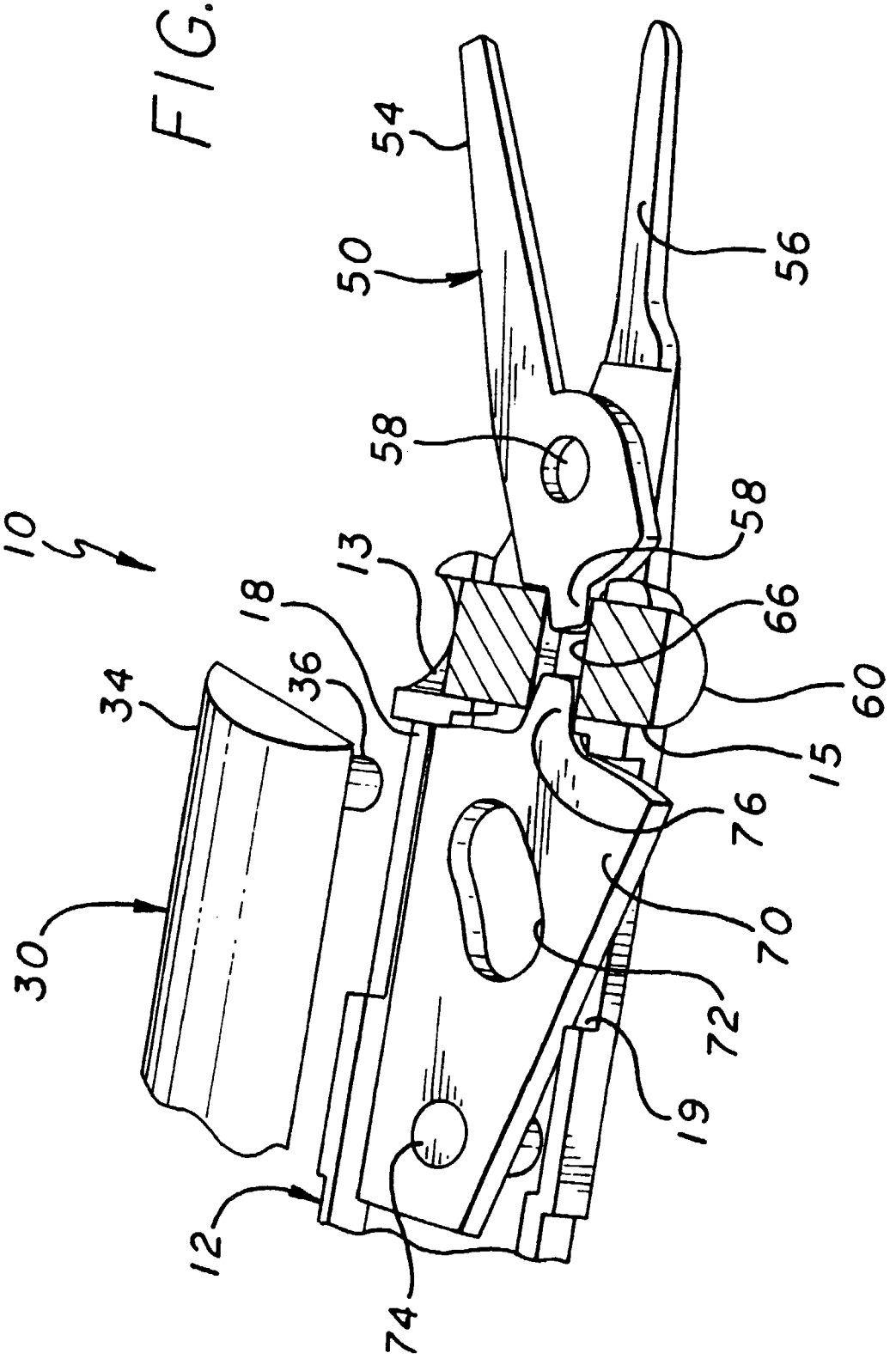


FIG. 2

FIG. 3



RIGIDLY-LINKED ARTICULATING WRIST WITH DECOUPLED MOTION TRANSMISSION

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is *a reissue of application Ser. No. 09/287,860, filed Apr. 7, 1999, now U.S. Pat. No. 6,132,441, which is* a continuation-in-part of application Ser. No. 09/262,134, filed Mar. 3, 1999, [pending] *now U.S. Pat. No. 6,436,107*, which is a continuation-in-part of application Ser. No. 08/873,190, filed Jun. 11, 1997, now U.S. Pat. No. 6,102,850, which is a continuation-in-part of application Ser. No. 08/755,063, filed Nov. 22, 1996, now U.S. Pat. No. 5,855,583. *This application is also the parent of divisional reissue application Ser. No. 11/948,052, filed Nov. 30, 2007, pending, and the parent of divisional reissue application Ser. No. 11/948,069, filed Nov. 30, 2007, pending.*

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to surgical devices. More particularly, the present invention relates to a device for suturing during the performance of minimally invasive endoscopic surgical procedures and more particularly to an articulating device for use in endoscopic coronary artery by-pass grafting surgery.

2. Description of Related Art

Blockage of a coronary artery may deprive the heart of the blood and oxygen required to sustain life. The blockage may be removed with medication or by an angioplasty. For severe blockage, a coronary artery bypass graft (CABG) is performed to bypass the blocked area of the artery. CABG procedures are typically performed by splitting the sternum and pulling open the chest cavity to provide access to the heart. An incision may be made in the artery adjacent to the blocked area. The internal mammary artery (IMA) or some other arterial source of blood-flow may then be severed and attached to the artery at the point of incision. The IMA bypasses the blocked area of the artery to again provide a full flow of blood to the heart.

Splitting the sternum and opening the chest cavity can create tremendous trauma on the patient. Additionally, the cracked sternum prolongs the recovery period of the patient. As such, there have been developed systems that enable minimally invasive CABG procedures. These systems utilize hand held tools and small incisions, on the order of 3-5 inches in length, to provide access to the thoracic region of a patient.

Such minimally invasive procedures are conducted by inserting surgical instruments through small incisions, on the order of inches in the skin of the patient. Manipulating such instruments can be awkward, particularly when suturing a graft to an artery. These systems utilize direct visualization of the surgical site. Such systems do not enable a completely endoscopic approach to the CABG procedure because of the need for direct visualization of the site. Additionally, such systems do not enable a fully endoscopic approach because of the incision size necessary to adequately manipulate the surgical instruments at the surgical site.

A fully endoscopic approach utilizes small holes to provide access to the thoracic cavity. Each of these holes is on the order of 3-11 mm in diameter. In order to perform a CABG procedure in a fully endoscopic fashion (i.e. using 3-11 mm holes) a robotic system must be used to filter hand tremors and scale motions made by the surgeon.

To facilitate the performance of an endoscopic surgical procedure, it would be useful to employ surgical instruments that can maneuver to the surgical site as well as manipulate tissue or sutures to perform an anastomosis.

To help minimize risk to the patient, and to minimize operating time, what is needed in the art is a robotically actuated surgical device that can articulate as well as actuate without being overly complex in design.

SUMMARY OF THE INVENTION

The present invention is an articulating device for tissue and needle manipulation, the device comprising:

An elongated housing having a proximal end and a distal end;

an articulation rod extending interior the housing, the articulation rod having a proximal end and a distal end;

an actuation rod extending interior the housing, the actuation rod having a proximal end and a distal end;

a rack driver in communication with the actuation rod at the distal end thereof, the rack driver engaged with a cylindrical rack for translating the motion of the actuation rod substantially about ninety degrees; and

a jaw in communication with the cylindrical rack, whereby movement of the cylindrical rack actuates the jaw, the jaw further in pivotal communication with the articulation rod such that linear movement of the articulation rod produces rotational movement of the jaw.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial break-away perspective view of a device in accordance with the present invention in a closed angled configuration;

FIG. **2** is a partial break-away perspective view of a device in accordance with the present invention in an open angled configuration;

FIG. **3** is a cross-sectional perspective view of a device in accordance with the present invention in an opened straight configuration;

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings more particularly by reference numbers, FIGS. **1**, **2** and **3** show a preferred embodiment of the articulating actuating device **10**. The device **10** includes a housing **12**. The housing extends substantially the length of the instrument **10** and has a proximal end **14** and a distal end **16** and a longitudinal axis X. Disposed interiorly the housing **12** is an articulation rod **20** and an actuation rod **30**. Each of the articulation rod **20** and the actuation rod **30** have respective proximal ends **22**, **32** and distal ends **24**, **34**.

The proximal ends **22**, **32** of the rods may be attached to a robotic system for the performance of minimally invasive surgical procedures. One such system is produced by Computer Motion, Inc. The assignee hereof and is described in U.S. Pat. No. 5,855,583, which is incorporated herein by reference.

The rods **20**, **30** are attached to actuators via attachment means taught in U.S. Pat. No. 5,855,583. Other means for removably attaching a rod to an actuator are known in the art

including the use of screws, clips or the like. In this way, each of the rods **20**, **30** may be driven by the actuator which is connected to various user interfaces and power sources and are conducive to the performance of minimally invasive surgical procedures.

The articulation rod **20** extends substantially the length of the housing **12** along its longitudinal axis X. The articulation rod **20** is pivotally connected to a jaw **50**. Such a pivotal connection may be accomplished through the use of a hinge **52** attached intermediate the articulation rod **20** and the jaw **50**.

The jaw **50** pivotally communicates with the housing **12** at the distal end **16** thereof through the use of a rack **60**. In this way, motion of the articulation rod **20** results in rotation of the jaw **50**. The rack **60** provides a pivot about which the jaw **50** rotates.

The actuation rod **30** provides for actuation of the jaw **50**. The actuation rod has a pin **36** disposed at the distal end **34** thereof. The pin **36** seats in a rack channel **72** disposed in a rack driver **70**. The rack driver is pivotally attached to the housing **12** via a pin **74** or the like. The housing has two longitudinal apertures **18**, **19** formed therethrough at the distal end **16** thereof to provide for lateral movement of the rack driver **70** which shall be described in detail hereinbelow.

Longitudinal motion of the actuation rod **30** moves the pin **36** in the rack channel **72** which translates the longitudinal motion of the actuation rod **30** into a pivotal motion of the rack driver **70**. The rack driver **70** pivots about the pivot point defined by the pin **74** which attaches the rack driver **70** to the housing **12**. The rack driver **70** may move outside of the space defined as the interior of the housing through the longitudinal apertures **18**, **19**.

The rack driver **70** has a shoulder **76** which engages the rack **60**. As the rack driver **70** pivots, the shoulder **76** causes the rack **60** to move laterally, which is orthogonal to the longitudinal motion of the actuation rod **30** and orthogonal to the longitudinal axis of the housing **12**. The rack **60** is slidably moveable within the housing **12** through two cylindrical apertures **13**, **15** formed therethrough. As the rack **60** moves laterally, the jaw **50** is actuated. The lateral movement of the rack **60** is transferred to a first jaw element **54**. A second jaw element **56** is pivotally connected to the first jaw element **54** via a pin **58** or the like and is held stationary with respect to the first jaw element **54**. In this way, as the first jaw element is **54** is moved, the second jaw element **56** remains stationary and the jaw **50** is actuated. If each element has a sharp edge, then the jaw may function as a scissors.

The jaw **50** is always in communication with the rack **60**, even as it is articulated through the motion of the articulation rod **20**. This is accomplished through the use of a cylindrical rack having a circumferential channel **66** formed therein. The channel **66** receives the shoulder **76** of the rack driver **70** as well as a shoulder **58** on the first jaw element **54**. As such, as the jaw **50** is articulated, the shoulder **58** on the first jaw element **54** rotates within the circumferential channel **66** in the rack **60** maintaining communication therein and providing for actuation of the jaw **50** regardless of the articulated position of the jaw **50** caused through motion of the articulation rod **20**.

In this fashion, the articulation of the jaw **50** and the actuation of the jaw **50** are decoupled. It is highly advantageous to provide for a rigidly linked device that is decoupled in this fashion for several reasons. First, the device is easily steralizable and secondly, the device is quite safe to use as there is no use of tensioned cables or the like.

While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art.

What is claimed is:

1. An articulating device for [tissue and needle manipulation] *medical intervention and surgery*, the device comprising:

[an elongated] *a* housing having a proximal end and a distal end;

an articulation rod [extending interior the housing, the articulation rod] having a proximal end and a distal end;

an actuation rod [extending interior the housing, the actuation rod] having a proximal end [and], a distal end, *and a longitudinal axis*;

a cylindrical rack adjacent the distal end of the housing;

a rack driver *adjacent the distal end of the housing, the rack driver* in communication with *the distal end of* the actuation rod [at the distal end thereof], the rack driver engaged with [a] *the* cylindrical rack [for translating the motion of the actuation rod substantially about ninety degrees] *to move the cylindrical rack orthogonally to the longitudinal axis*; and

a jaw *adjacent the distal end of the housing, the jaw* in communication with the cylindrical rack, [whereby movement of the cylindrical rack] *the cylindrical rack being orthogonally movable relative to the longitudinal axis to* actuate[s] the jaw, the jaw further in pivotal communication with *the distal end of* the articulation rod such that linear movement of the articulation rod produces rotational movement of the jaw;

the actuation rod coupled to a pin, the pin confined to a rack channel on the rack driver.

* * * * *