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Michelson

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(54) **SURGICAL RONGEUR**

(75) **Inventor:** **Gary Karlin Michelson**, 438 Sherman Canal, Venice, CA (US) 90291

(73) **Assignee:** **Gary Karlin Michelson**, Venice, CA (US)

(*) **Notice:** This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) **Appl. No.:** **09/570,754**

(22) **Filed:** **May 15, 2000**

Related U.S. Application Data

(63) Continuation of application No. 08/905,360, filed on Aug. 4, 1997, now Pat. No. 6,142,997, which is a division of application No. 08/337,107, filed on Nov. 10, 1994, now Pat. No. 5,653,713, which is a continuation-in-part of application No. 08/108,908, filed on Aug. 18, 1993, now Pat. No. 6,200,320, which is a continuation-in-part of application No. 07/905,127, filed on Jun. 24, 1992, now abandoned, which is a continuation of application No. 07/398,987, filed on Aug. 28, 1989, now abandoned, which is a continuation-in-part of application No. 07/341,849, filed on Apr. 24, 1989, now Pat. No. 5,009,661.

(51) **Int. Cl.⁷** **A61B 17/32**

(52) **U.S. Cl.** **606/83; 606/170; 606/184**

(58) **Field of Search** **606/83, 184, 170, 606/205; 600/564**

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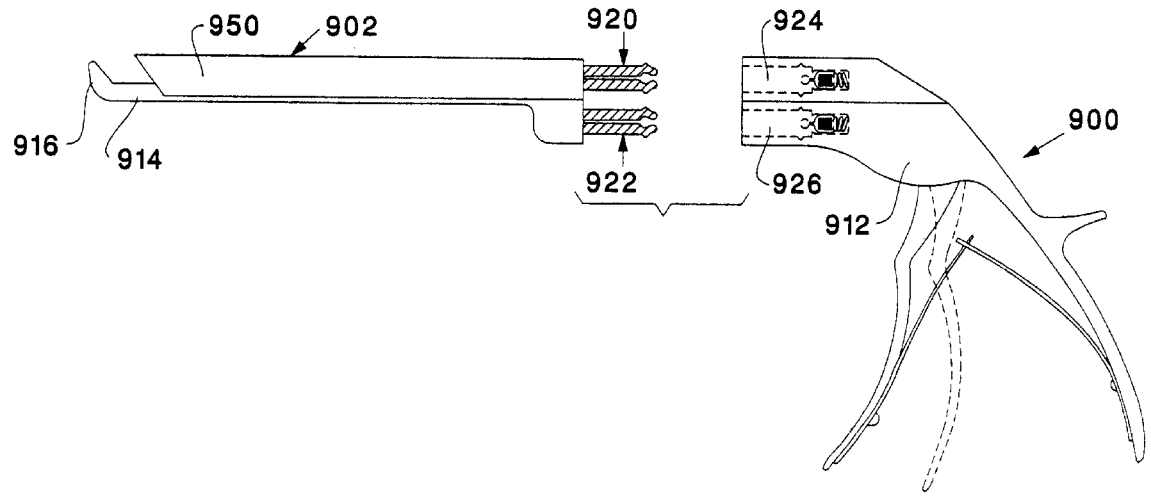
Primary Examiner—Michael H. Thaler

(74) *Attorney, Agent, or Firm*—Martin & Ferraro, LLP

(57) **ABSTRACT**

An improved rongeur for cutting bone or cartilage comprising two shaft members capable of reciprocating motion relative to each other wherein one shaft member terminates in a foot plate and the other shaft member comprises a combined cutting element and storage member is disclosed. The combined cutting element and storage member has a cutting edge at its distal end and a storage chamber proximate the cutting edge for collecting and storing cut pieces of bone or cartilage in an amount greater than the maximum bone or cartilage capable of being cut in a single full cut. The combined cutting element and storage member is truly disposable, rather than merely replaceable and requires the use of no tools or special assembly. The rongeur may be manually activated or activated by a solenoid and powered by a battery.

24 Claims, 16 Drawing Sheets



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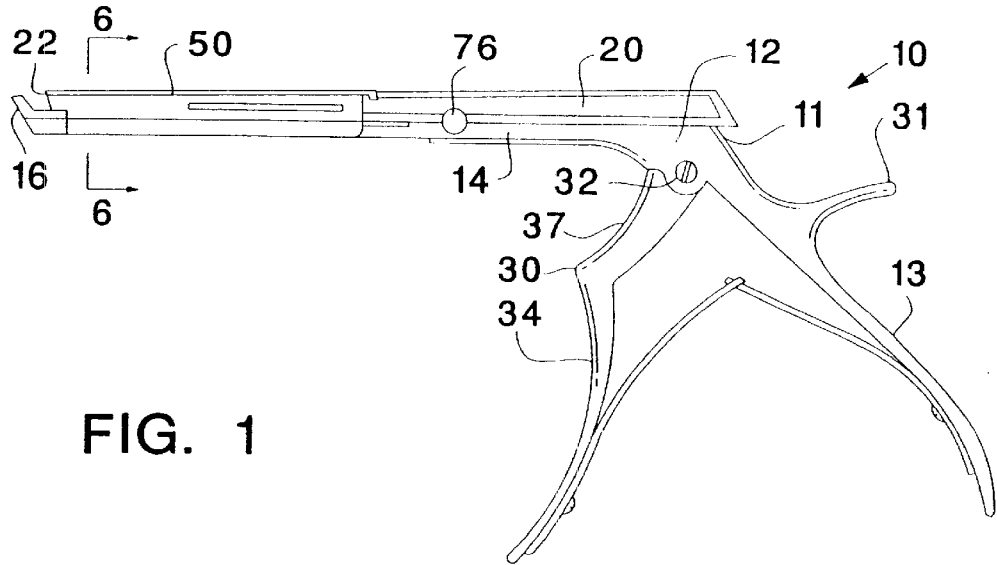
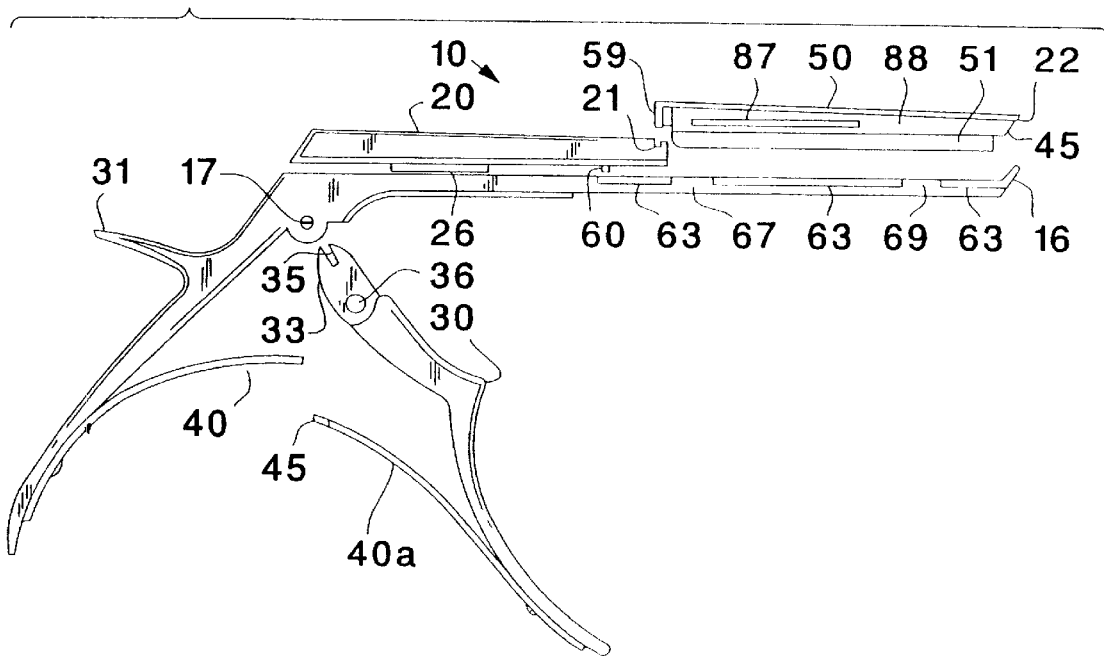


FIG. 3



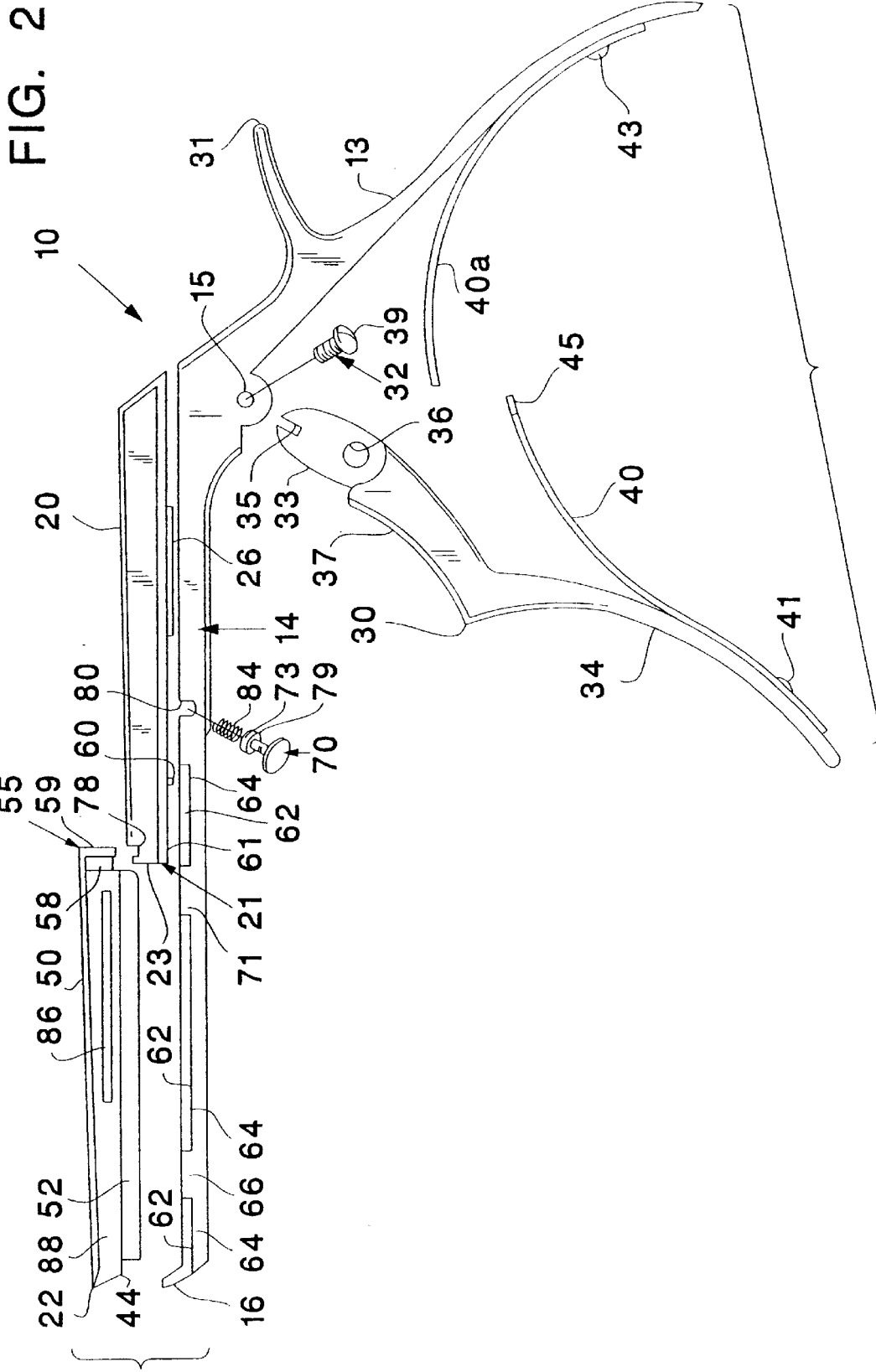
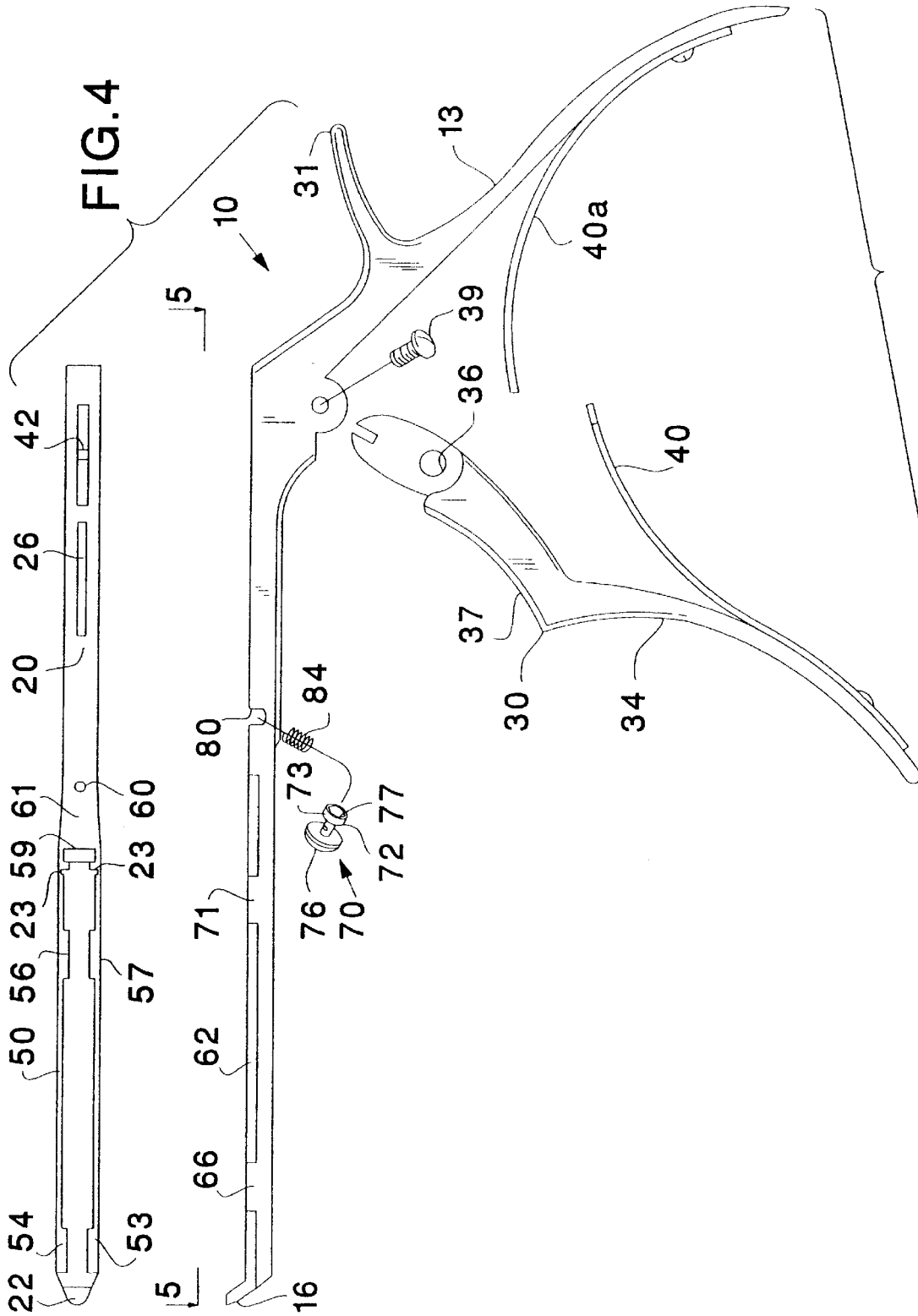


FIG. 2



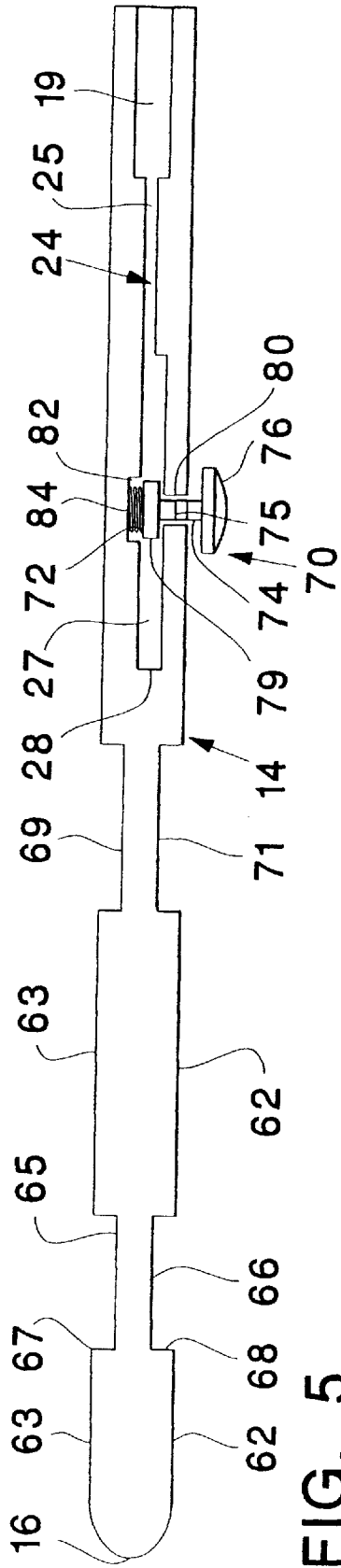


FIG. 5

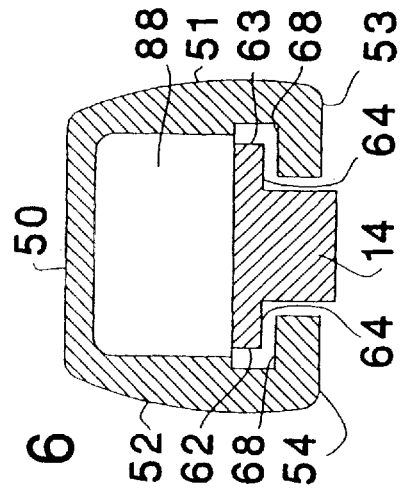


FIG. 6

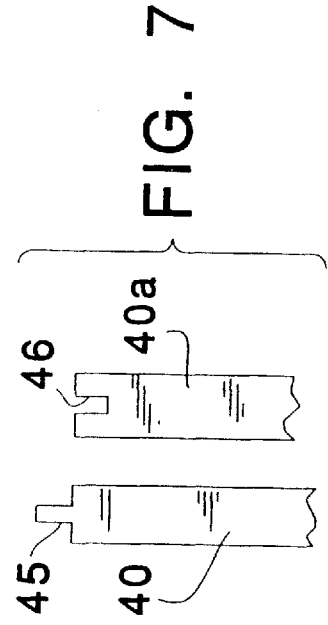


FIG. 7

FIG. 8

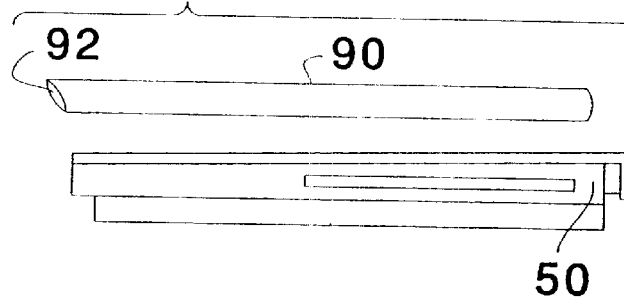


FIG. 9

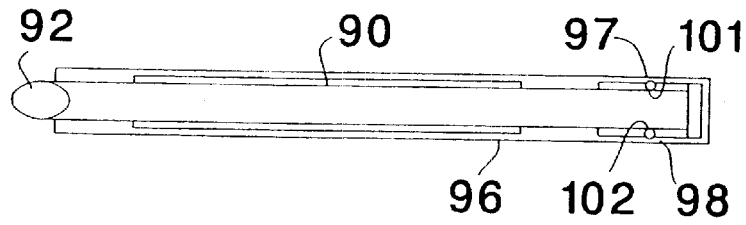


FIG. 10A

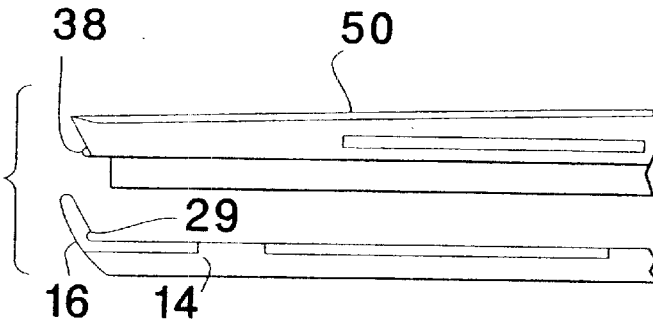
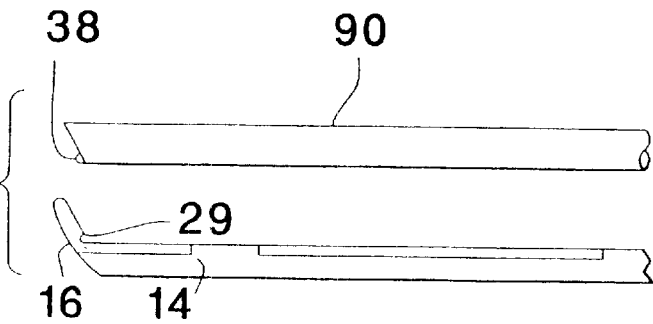


FIG. 10B



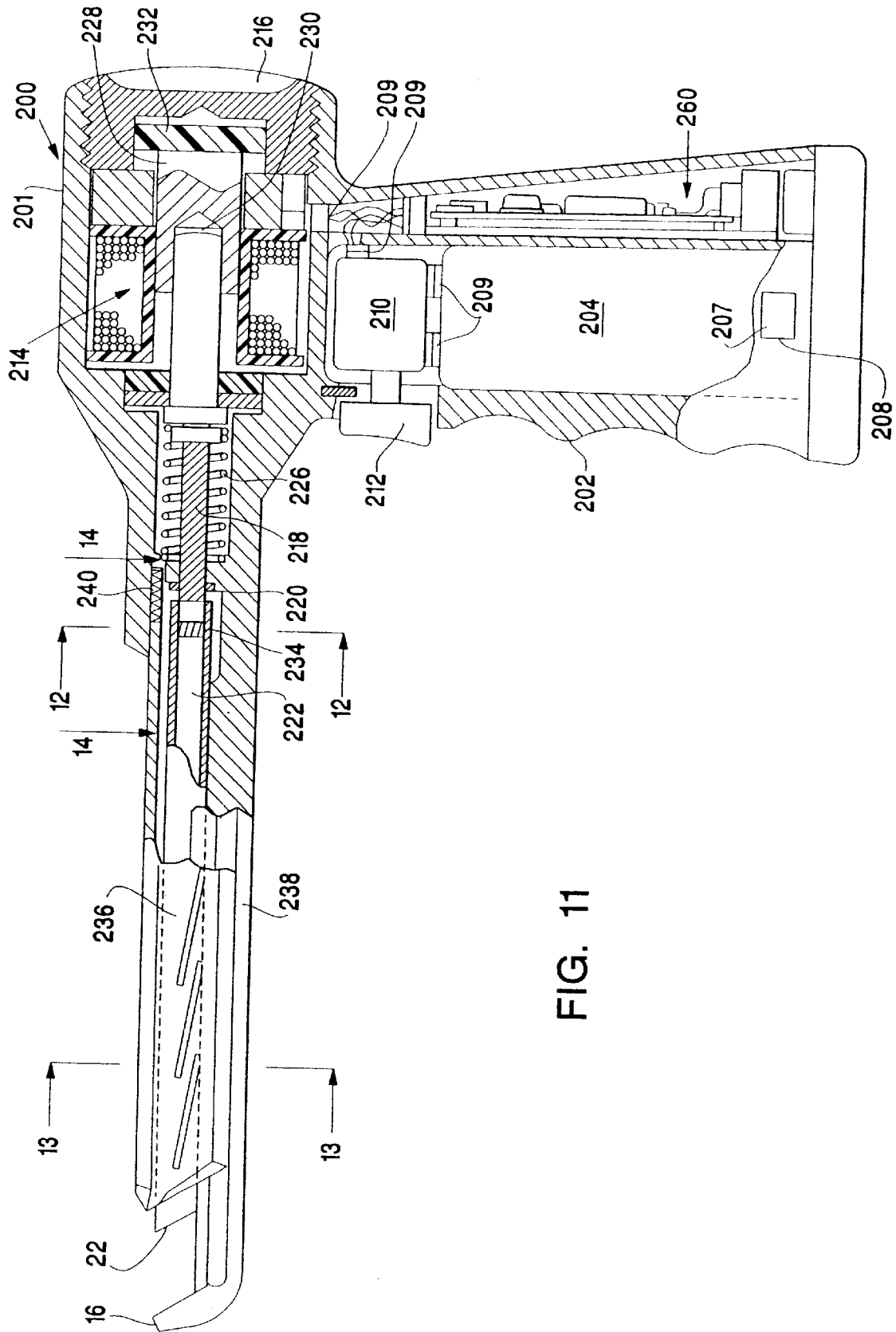


FIG. 11

FIG. 12

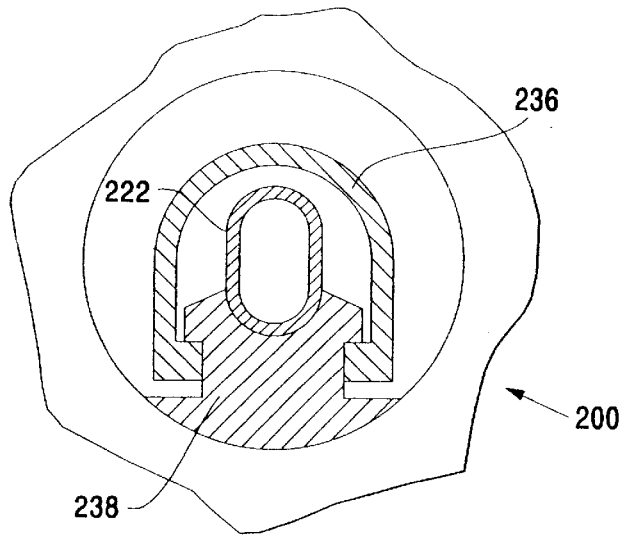
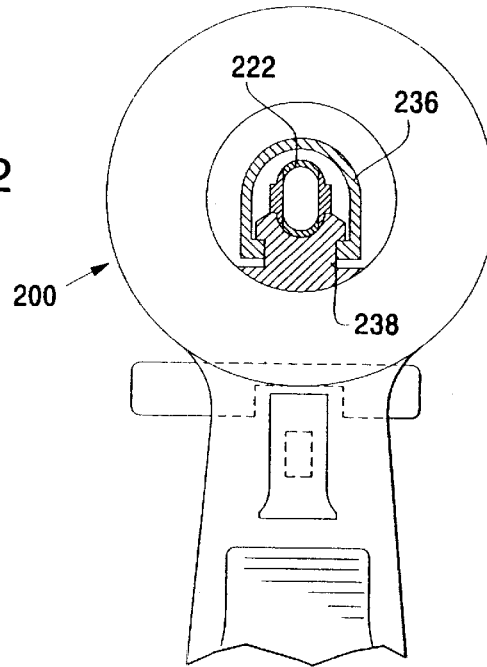
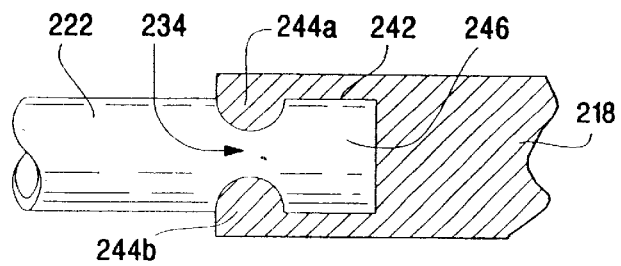


FIG. 13

FIG. 14



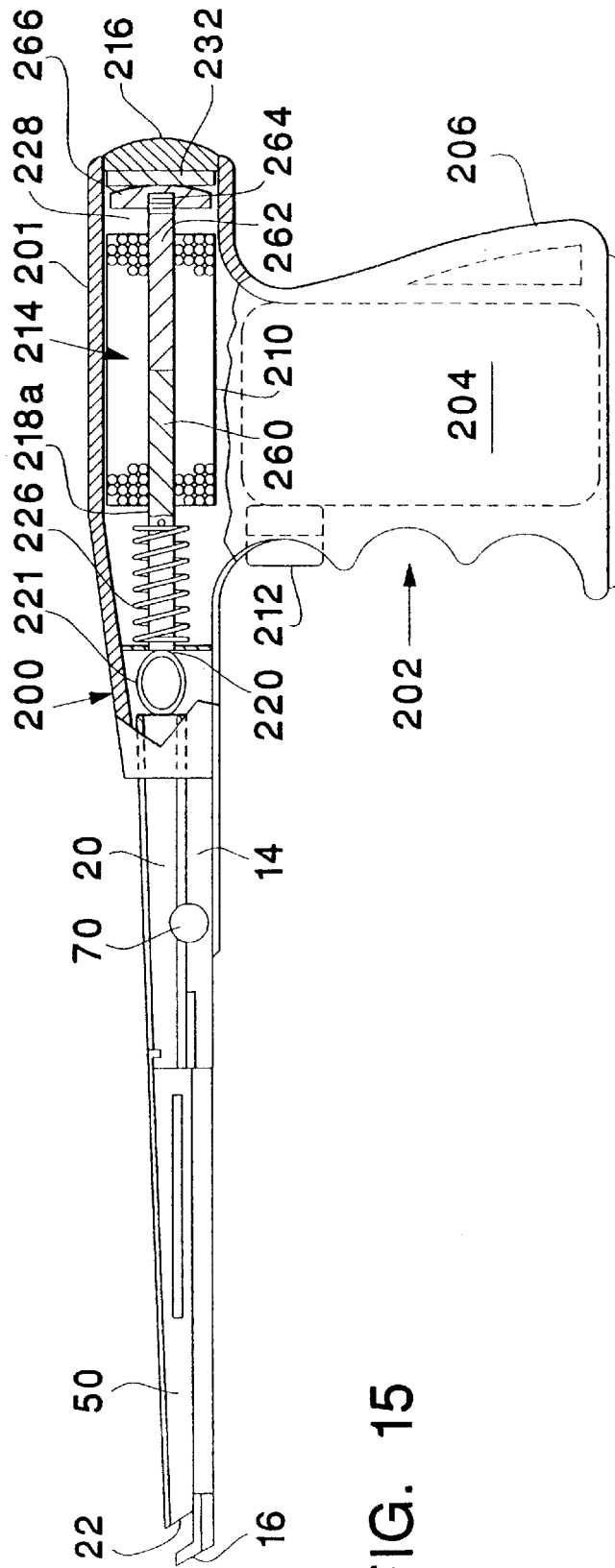


FIG. 15

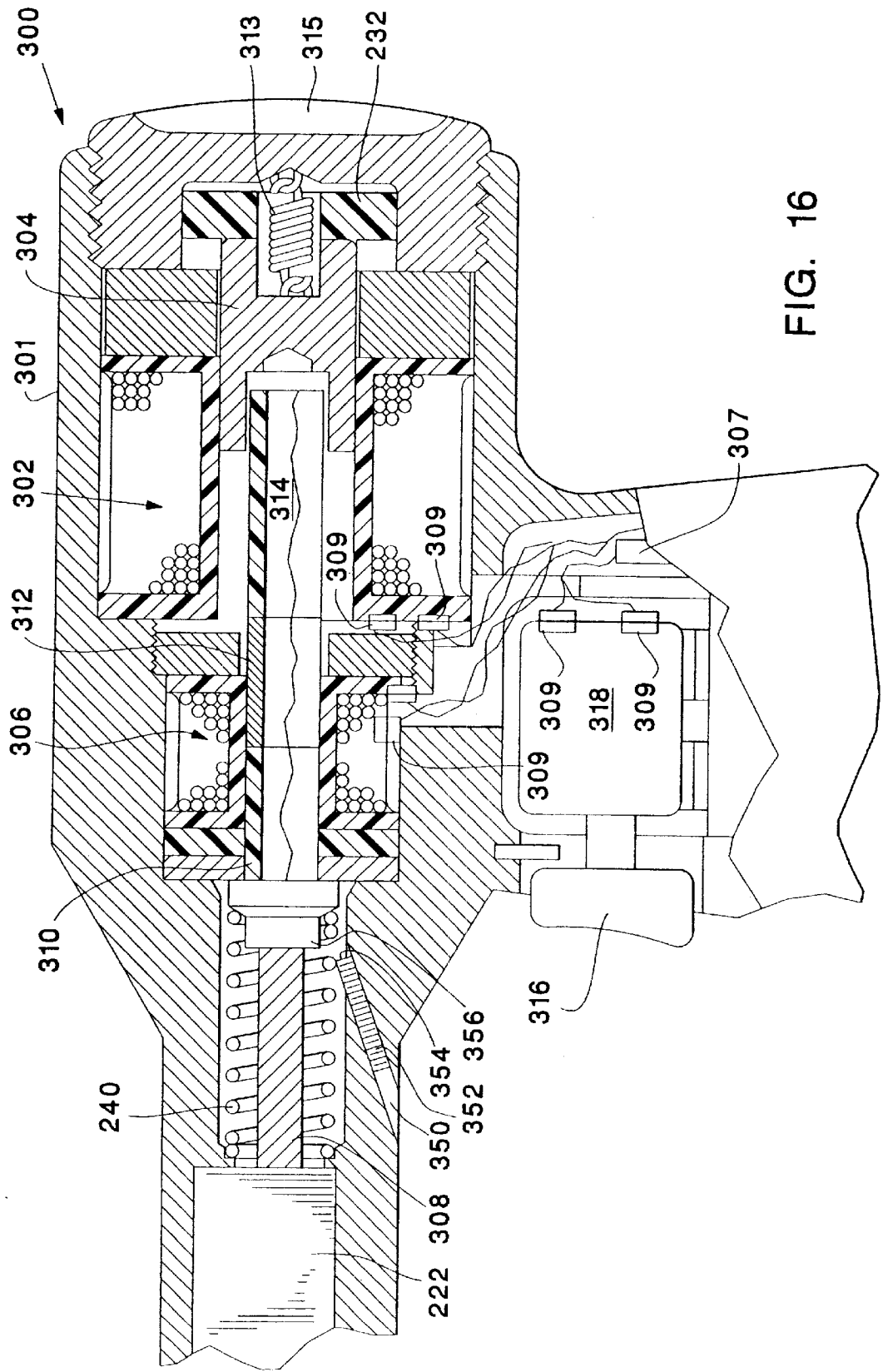


FIG. 16

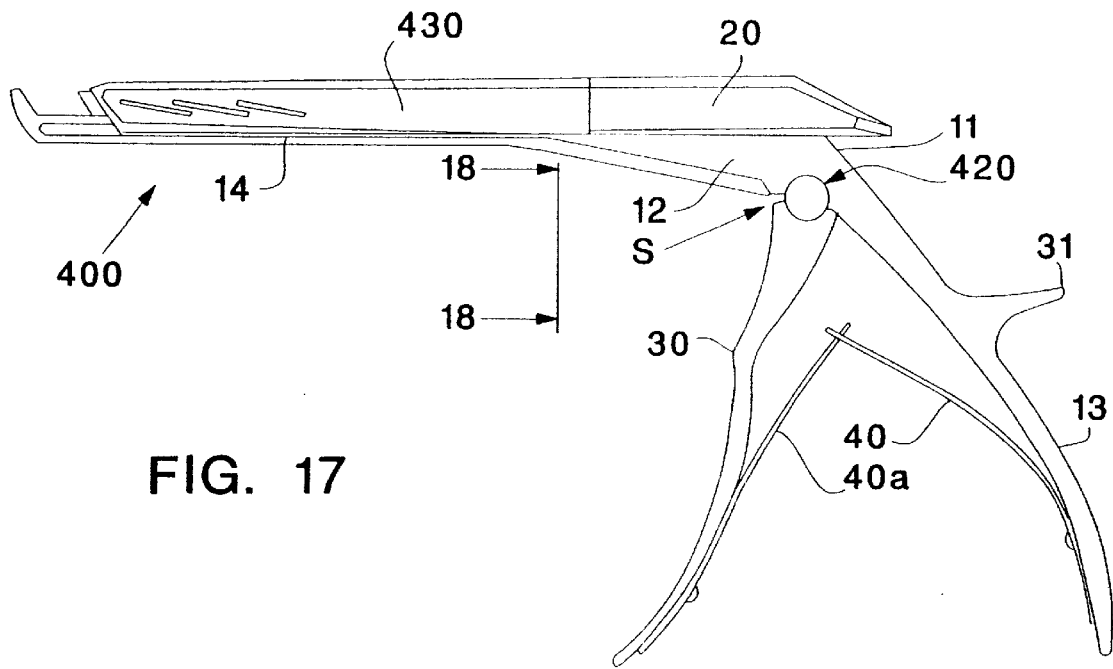


FIG. 17

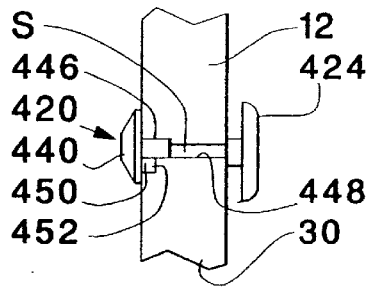


FIG. 18

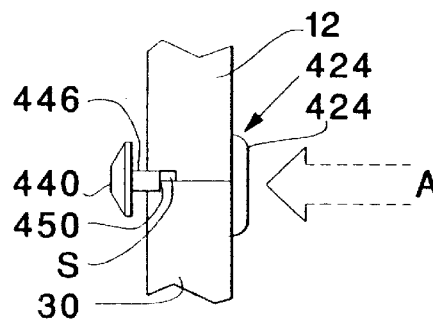


FIG. 19

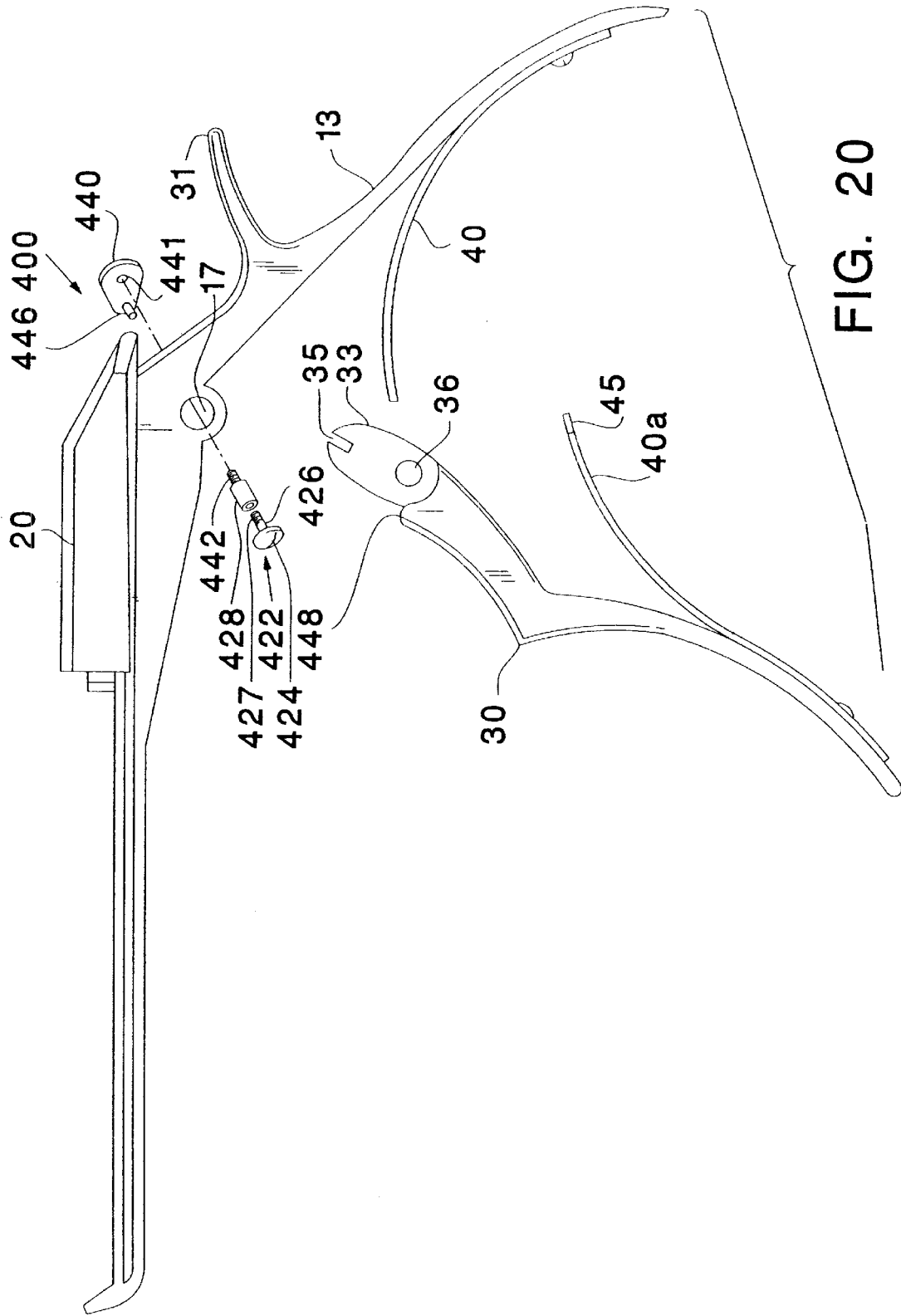


FIG. 20

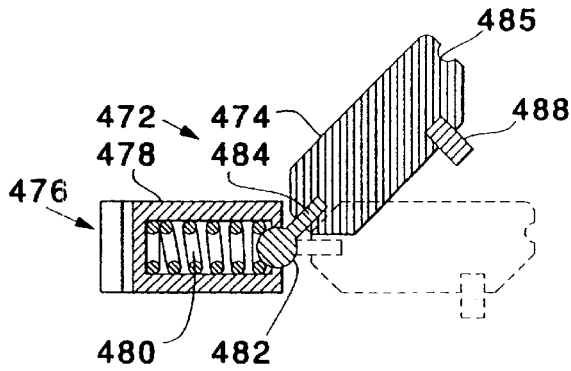
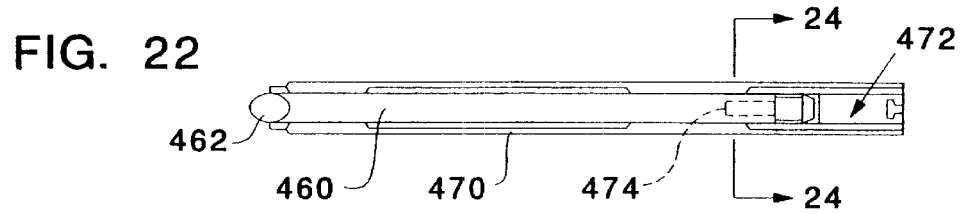
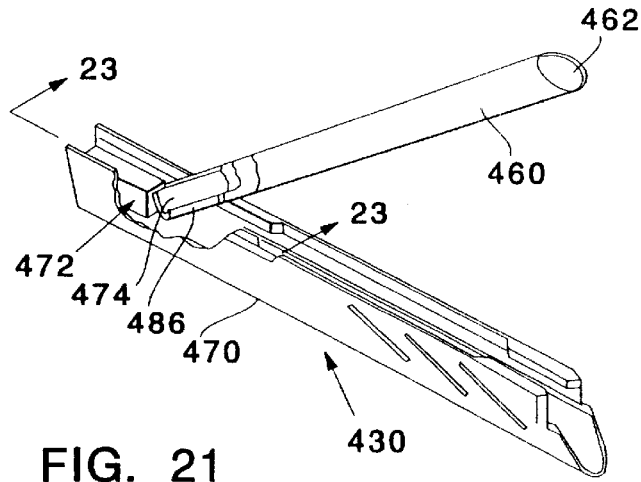
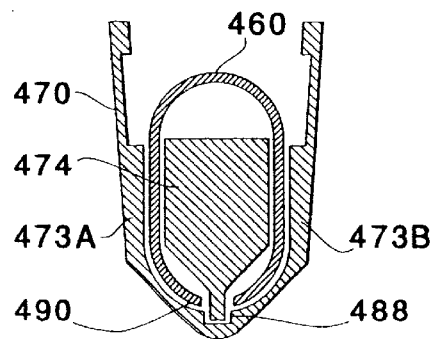
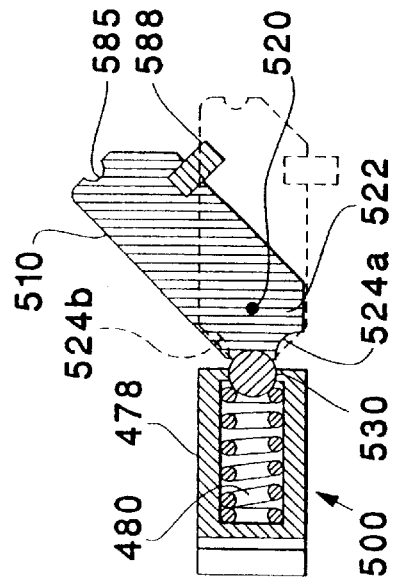
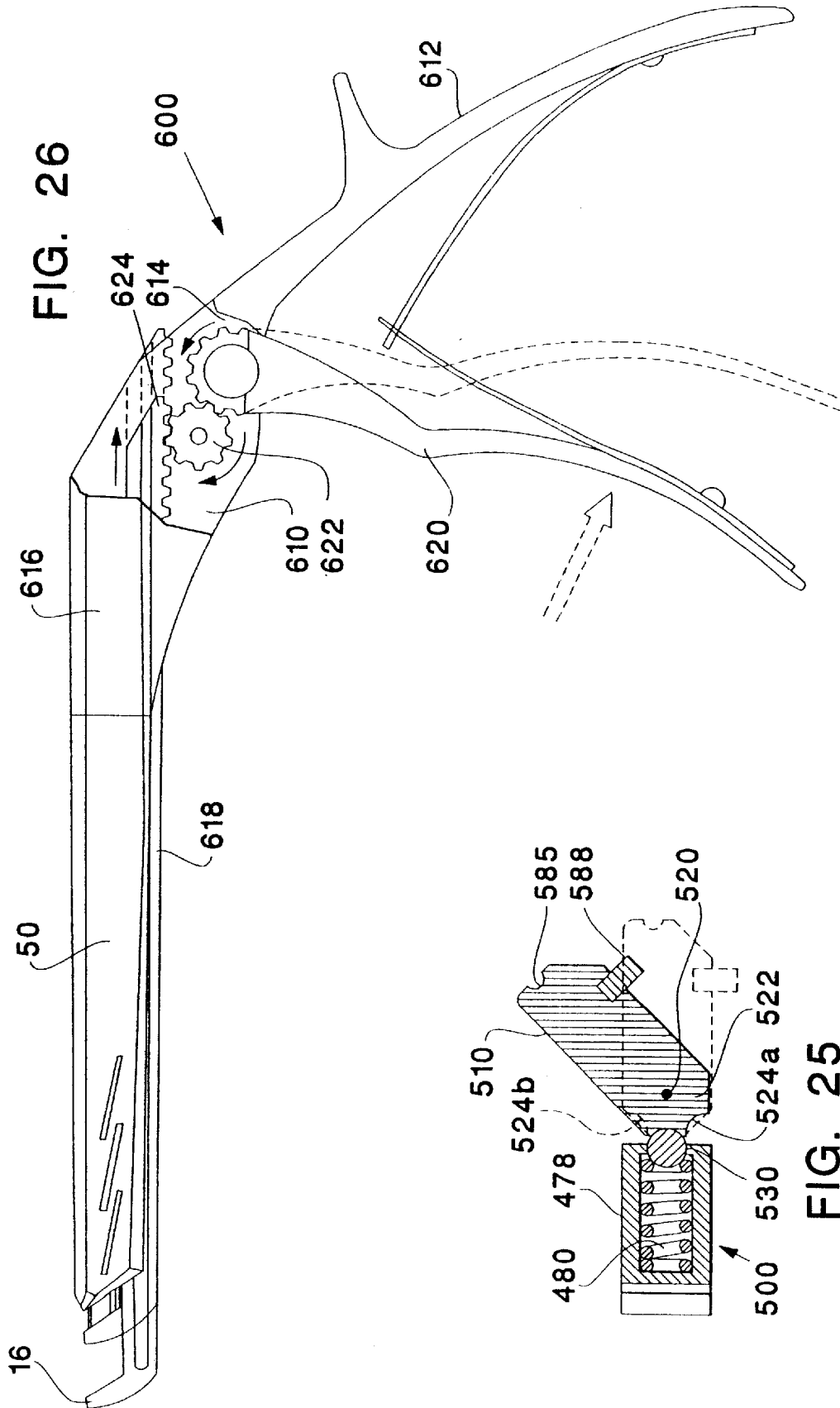


FIG. 24





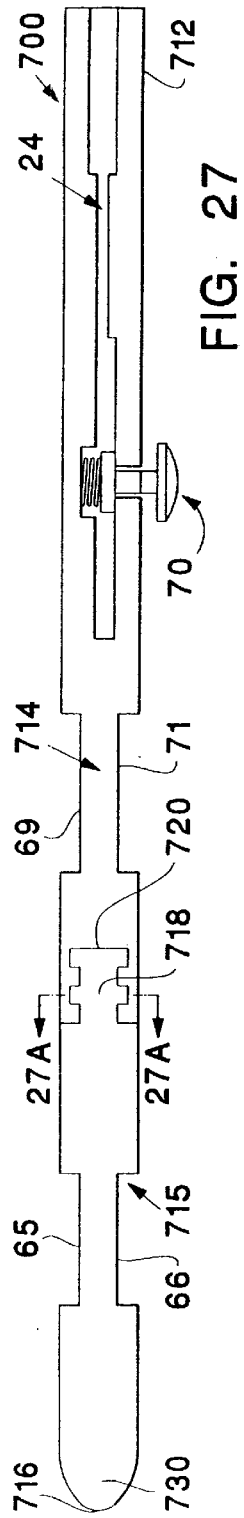


FIG. 27

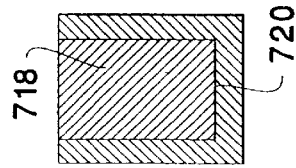


FIG. 27A

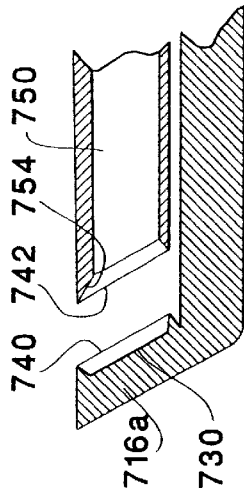


FIG. 27B

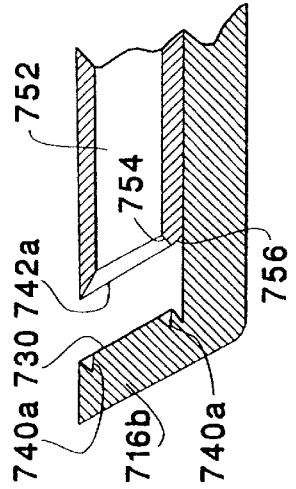


FIG. 27C

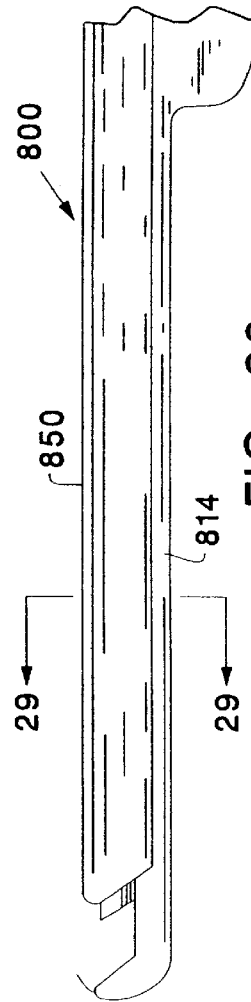


FIG. 28

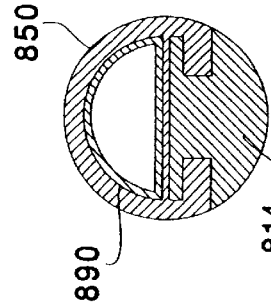


FIG. 29

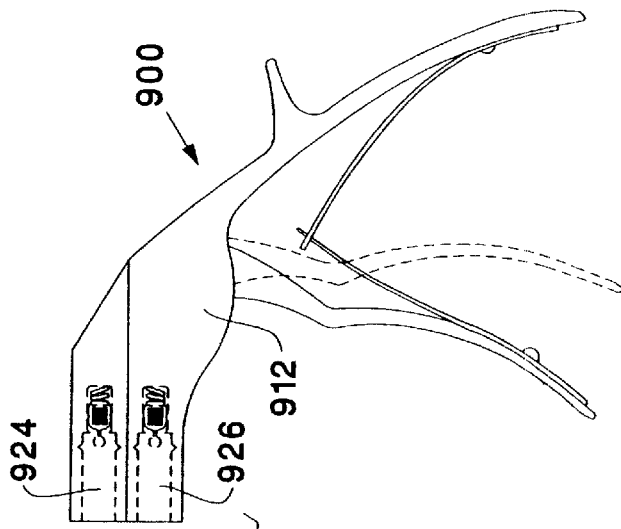


FIG. 30

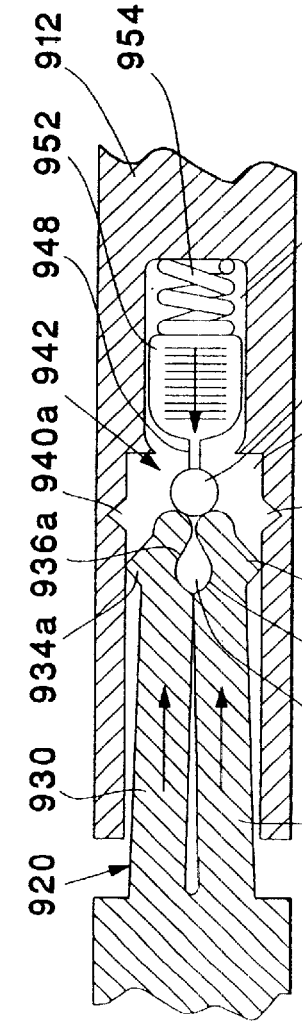


FIG. 31

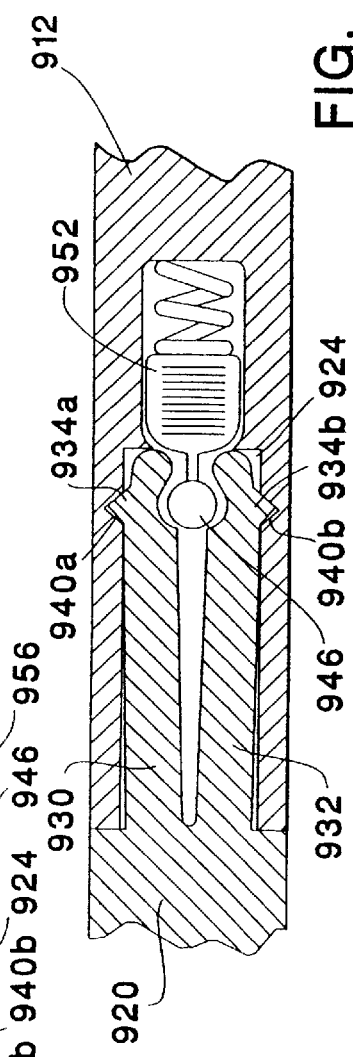


FIG. 32

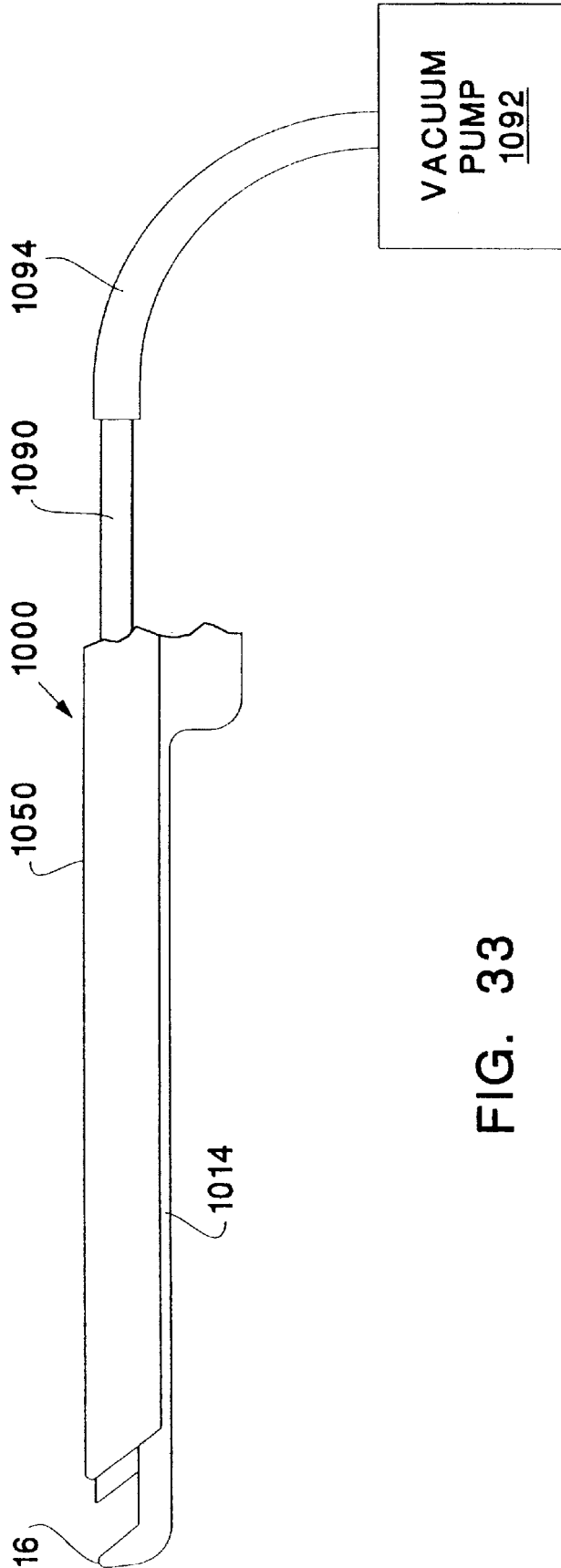


FIG. 33

SURGICAL RONGEUR

This is a continuation of application Ser. No. 08/905,360, filed Aug. 4, 1997, now U.S. Pat. No. 6,142,997 which is a divisional of application Ser. No. 08/337,107, filed Nov. 10, 1994, now U.S. Pat. No. 5,653,713 all of which are incorporated herein by reference, which is a continuation in part of application Ser. No. 08/108,908 filed on Aug. 18, 1993, now U.S. Pat. No. 6,200,320 which is a continuation in part of application, Ser. No. 07/905,127, filed on Jun. 24, 1992, now abandoned which is a continuation of application, Ser. No. 07/398,987, filed on Aug. 28, 1989 now abandoned which is a continuation in part of application, Ser. No. 07/341,849, filed on Apr. 24, 1989 now U.S. Pat. No. 5,009,661.

BACKGROUND OF THE INVENTION**1. Field of the Invention**

This invention relates to surgical instruments, used to bite out or cut portions of bone or cartilage, and specifically to those of the Kerrison type, or similar type.

2. Description of the Related Art

Rongeurs are surgical instruments for the cutting away of human tissue, and most commonly, cartilage and/or bone. Kerrison rongeurs are utilized in spinal surgery to remove bone and to thereby gain access to the spinal canal. These rongeurs typically have a closable jaw, one member of which having a cutting end and the other member being a foot plate which must be placed beneath the tissue, generally bone or cartilage, to be cut.

For example, when a Kerrison rongeur is in use, the surgeon places the bone to be cut, such as the leading edge of the lamina of a vertebrae, within the open portion of the distal end of the rongeur. The surgeon then squeezes the handle of the rongeur which causes the moveable jaw member of the rongeur to be advanced through that portion of bone to reach the foot plate, and thereby amputating that portion of bone. Once the jaw members become full, the rongeur must then be completely removed from the surgical site and passed to the scrub nurse for the removal from the instrument of that cut portion of bone.

To facilitate the necessary function of the rongeur, the foot plate is generally cupped, as is the cutting end of the moveable jaw member. If only the moveable jaw member were cupped and the foot plate flat, then upon cutting with such an instrument the bone would be so compacted into that singular cup as to make it nearly impossible to remove the portion of bone cut. However, because the foot plate of the Kerrison rongeur is below the lamina and proximate to the dural sac, spinal cord, and nerve roots, there is a compelling need to avoid any excessive thickness of the foot plate itself. Therefore, the foot plate cup is generally not quite as deep as the cup in the moveable jaw member and thus, even in the double cup design, the cut portion of bone tends to be compacted proximally, making its removal nevertheless difficult. The removal from the instrument of the cut portion of bone often requires that the scrub nurse use a small rigid hook, or toothed forceps, and often further requires that the physician temporarily relinquish the instrument entirely to make such bone removal possible. Once cleaned, the instrument is returned to the surgeon who, in returning it to the surgical site, must then reorient himself to the task at hand. This sequence must then be repeated over and over again with each cut of bone. Typically, such spinal procedures unfortunately require many such cuts.

Essentially flat foot plates had been in use earlier this century, but proved to be undesirable because the opening of

the jaw members to be able to get around the thickened portions of the vertebrae tended to exceed the capacity of the cup in the moveable jaw member and the bone cut would be markedly compressed during the cutting process. When the foot plate is flat, the mass of bone bitten is forcefully compacted into the singularly cupped recess of the movable jaw member such that it is extremely difficult to remove that bone after each cut.

A consideration of the structure and function of the prior art rongeurs, and specifically in regard to the foot plate structure and its requisite thickness, is quite revealing. It would appear that in use the foot plate is subjected to five types of forces.

Consistent with its intended purpose, the foot plate is subjected to, and must withstand, that force necessary to actually cut through the bone, which shall be referred to as the Bone Cutting Force. However, the surgeon has no way of knowing what that force is, or even when he has reached or exceeded it. Accordingly, the foot plate is invariably exposed to a second force significantly greater than the Bone Cutting Force which shall be called the Terminal Squeezing Force. The Terminal Squeezing Force occurs after the bone fragment has been cut and is caused by the surgeon generating force in excess of the Bone Cutting Force. This results in the relatively massive slide portion of the instrument being driven with great mechanical advantage against the foot plate. This occurs because the manufacturer of such a rongeur must allow for wear of the cutting surfaces and still allow for the jaw to still be able to close such that the slide portion of the instrument has a greater excursion than would be otherwise required to merely close the jaw members of the rongeur when the cutting surfaces are new.

A third force encountered by the foot plate is a product of the fact that the instrument jaw generally opens to an extent greater than the combined depths of the cups such that the solid bony contents are physically crushed. This is the Bone Crushing Force, and again is additional to the Bone Cutting Force.

A fourth force that may impact upon the foot plate is that which occurs when the jaws of the rongeur encounter an object, which because of its physical structure, is unbiteable. In this situation, while the jaw is still in a relatively open position, again a force greater than the Bone Cutting Force is generated and in this case is then transmitted through the unbiteable object to the foot plate.

The fifth force to which the foot plate is subjected is leverage. When the jaws are not sufficiently sharp, or are worn such that they fail to completely close, then the bone will not be completely cut through, and the surgeon will rock the instrument back and forth to fracture through the remaining bony bridge. In this situation, the angle of the jaw in contact with the leading edge of the lamina becomes the fulcrum point and the foot plate, measuring generally less than half of an inch in length, is one lever arm, while the remainder of the instrument through the shaft and handle is the other. Since these instruments generally measure on the order of approximately 10 inches, the mechanical advantage, or force applied to the tip in a rocking maneuver is on the order of magnitude of 20 to 1.

The ability to safely withstand repeated exposure to these five forces, and the previously discussed need to cup the inner surface of the foot plate, have in the past, determined the requisite thickness of the foot plate.

At present, there is also a need for a rongeur with a capacity to remain within the wound and to repeatedly bite bone and to store the bone bitten until all the requisite bone

removal has been completed without the need to continuously remove the rongeur from the wound for the purpose of removing the cut portion of bone from the instrument to clear the cutting edges. A further and related need exists for a rongeur that would collect and contain all of the bitten material such that the delicate neural structures would be protected from contact with the bitten material and/or any cogenerated inadvertent debris. In this regard, any rongeur can bite more than once, but not properly. That is, one could deliberately take several small bites, each of which would fail to fill the cup in the foot plate and the singularly cupped recess of the moveable jaw member, in lieu of taking one full bite. However, once the cup in the foot plate and the cupped recess of the moveable jaw member are filled, further biting is not possible. Bone may be crushed as cups that are already full approach one another, but their contents will shield any further interposed bone from the cutting edges, thus making any further bone cutting impossible.

An example of a multibite rongeur is shown in U.S. Pat. No. 3,902,498 issued to Niederer on Sep. 2, 1975. Niederer teaches the use of a rongeur hollow at the tip such that it is possible to take several bites. Unfortunately, since the hollow tip is open to the wound at both ends, the further use of the instrument pushes the already bitten material out of the other end of the hollow tip and back into the depths of the surgical wound where it can cause great harm. This shortcoming of Niederer can not be overcome by simply closing off the second opening as the operation of the instrument requires the second cutting member (8) to pass through the same area that the ejected bone had occupied.

Further, if a rongeur could take and then store safely, multiple full bites of bone, a rationale would then exist for a power rongeur. A prior art power rongeur was marketed by the 3M Company. However, it was very bulky and required a large bore hose connection to a non-sterile compressed gas tank making the instrument very unwieldy. The biting mechanism itself was rather slow and clumsy and the instrument still required removal from the wound after every bite to clean out the bitten portions of bone.

There is also a need for a disposable cutting means so that those portions of the rongeur involved in the actual cutting may be easily renewed as these portions of the rongeur rapidly wear and dull from the cutting of bone. With wear comes both edge dullness and non-mating of the contact surfaces rendering the rongeur ineffective and even dangerous as it fails to cut cleanly and begins to rely on tearing.

Both U.S. Pat. No. 3,902,498 issued to Niederer and U.S. Pat. No. 5,026,375 issued to Linovitz et al. disclose a means for replacing the cutting element on just one side of the jaw in a rongeur appearing to have cutting cupped portions on both sides of the jaw. Since dulling and wear occurs equally on both sides of the jaw, replacing only one side is obviously ineffective in restoring the sharpness and the full cutting function of the instrument or for even providing for the proper mating of the cutting surfaces as one new side is then opposed to one worn side.

Reference is made to U.S. Pat. No. 4,722,336 to Wright et al. and U.S. Pat. No. 4,777,948 to Wright et al. U.S. Pat. No. 4,777,948 discloses a rongeur having a stationary hollow tubular cutting element **28** which may be removably attached to the rongeur. The entire assembly must be disengaged to replace the cutting element. The device is not capable of taking multiple full bites since only a short recess is provided for pulling the severed bone into the hollow cutting tube and contrary to that concept teaches that the bone is then ejected after each cutting operation, as

explained in U.S. Pat. No. 4,722,338 at Col. 3, line 10. No collection of the cut bone is achieved by the hollow cutting element beyond a single cut and the cut bone is then ejected. In fact, the cut bone may be ejected into the wound, which could cause great harm.

Finally, there is a need for a Kerrison type rongeur that is capable of taking larger bites of bone than is now possible. While the need for such a rongeur exists, by prior art technology the foot plate would be too thick to safely use beneath the lamina, and the surgeon would lack the strength to crush and compact that volume of bone.

There is therefore a need for a Kerrison type rongeur with a thin, but strong, foot plate that would be able to take and safely store throughout the operation multiple full bites of bone. Such a rongeur would also have at least a disposable cutting element system capable of replacing all cutting edges to provide for the surfaces of the cutting edges to be sharp and close perfectly and would be capable of taking larger bites of bone than previously possible. Such a rongeur could be powered without the need for external connections to a remote power source.

SUMMARY OF THE INVENTION

The present invention is a rongeur for cutting bone or cartilage comprising two shaft members capable of reciprocating motion relative to each other wherein one shaft member terminates in a foot plate and the other shaft member comprises a combined cutting element and storage member. The combined cutting element and storage member has a cutting edge at its distal end and a storage chamber proximate the cutting edge for collecting and storing cut pieces of bone or cartilage in an amount greater than the maximum bone or cartilage capable of being cut in a single full cut. In one embodiment of the present invention the surgical rongeur is an ultra-thin foot plate, multi-bite (capable of taking multiple full bites) rongeur with a combined cutting element and storage member that is replaceable and disposable. The combined cutting element and storage member comprises a removable and disposable straw member having a sharp cutting end and an end that removably attaches to an engagement means for engaging the straw member to a carriage member such that the end is closed while in use. The combined cutting element and storage member is removably locked to at least one of the two shaft members.

The reciprocating motion of the two shaft members causes the combined cutting element and storage member and a foot plate to close and open in response to the activation of a driving member which may be hand operated or powered by a solenoid. The foot plate of the rongeur of the present invention is ultra-thin, such that it is substantially thinner than the foot plates of the rongeurs of the prior art. The ultra-thin foot plate of the present invention is made possible by the relative absence of any recess sufficient to hold bone after a cut is made and is substantially flat. The foot plate of the present invention need not be as thick as that of a conventional rongeur since the only force normally applied to it is that sufficient to actually cut the bone being bitten.

In one embodiment of the present invention, the foot plate-shaft junction area of the rongeur is designed to prevent the upward excursion of the combined cutting element and storage member along the foot plate. The terminal squeezing force is eliminated by providing a proximal stop to the movement of the slide portion of the instrument allowing only for the full opposition of the foot

plate and combined cutting element and storage member but allowing no further motion. This absence of further motion in opposition to the foot plate thus serves to consequently protect it.

The bone compaction force that occurs with prior art rongeurs results from the fact that the rongeur must—to serve its purpose—open to an extent sufficient to accept the thickness of the bone being cut, which commonly exceeds the capacity of the two cupped surfaces. However, the present invention has no fully cupped surfaces and in fact the combined cutting element and storage member is functionally bottomless until full.

The force associated with levering is eliminated by eliminating the need for it which generally arises from a need to complete the cutting out of a piece of bone by fracturing through the remaining portion when such cutting is incomplete because of dulling of the cutting elements or a failure of them to fully and uniformly coapt. In the instance of the present invention as the cutting element is not only replaceable, but disposable, and as there is but a single cutting element which is replaceable for each new procedure the surgeon is assured that all of the cutting surfaces are optimally sharp and unworn such that those biting surfaces coapt perfectly. Prior art rongeurs that replaced but one of two equally important cutting edges failed to either restore full sharpness or to provide for perfect coaptation of those cutting surfaces.

During use, the combined cutting element and storage member is closed at its proximal end and open at its distal end terminating in an ultra-sharp cutting surface. Inasmuch as the combined cutting element and storage member is hollow, rather than cupped, and the opposed surface of the foot plate is substantially flat, the bone bitten is always driven rearward into the storage member portion. As the storage chamber is closed while in use except for the cutting entrance, it may be used to repeatedly bite bone without the danger of the bone bitten coming free and falling into the spinal canal in contradistinction to prior art rongeurs which required the ejection of bone before a second full bite could be taken.

When the present invention has completed its task and has removed all of the bone as needed, the combined cutting element and storage member may be removed from the shaft of the rongeur and the bitten bone may be removed from the storage member and made available for use, as in performing a spinal fusion.

The present invention allows for the clean cutting of bone or cartilage without any significant compaction. Further, as the combined cutting element and storage member of the present invention is disposable and thus always fresh and sharp, less force is required during the actual cutting of the bone. In addition, since the combined cutting element and storage member is always fresh and sharp, edge wear is not a problem and the capacity for further excursion of the combined cutting element and storage member towards the foot plate is unnecessary and may be completely blocked, thereby sparing damage to the foot plate.

Further, the present invention has a combined cutting element and storage member that is truly disposable, rather than merely replaceable and requires no special assembly or the use of any tools. The combined cutting element and storage member is simply placed onto one of the shaft members whereby it is immediately locked into place by the use of the instrument itself.

Finally, as the rongeur of the present invention is capable of taking repeated and uninterrupted multiple full bites of

bone or cartilage, there is a compelling rationale for the incorporation of a power means to drive the rongeur and a self-contained power source to further allow the use of the rongeur to be unfettered.

OBJECTS OF THE PRESENT INVENTION

It is an object of the present invention to provide an improved surgical rongeur capable of taking multiple full bites of bone or cartilage without having to be removed from the wound after each bite.

It is another object of the present invention to provide an improved surgical rongeur capable of storing multiple cut pieces of bone or cartilage while the rongeur is in the wound.

It is yet another object of the present invention to provide an improved surgical rongeur having a combined cutting element and storage member.

It is a further object of the present invention to provide an improved surgical rongeur having a combined cutting element and storage member that is easily replaceable and disposable.

It is yet a further object of the present invention to provide an improved surgical rongeur having a replaceable and disposable combined cutting element and storage member that does not require the use of tools or special assembly.

It is still a further object of the present invention to provide an improved surgical rongeur having a combined cutting element and storage member which is simply placed onto the shaft of the rongeur, whereby it is immediately locked into place by the use of the rongeur.

It is another object of the present invention to provide an improved surgical rongeur with an ultra-thin foot plate. It is a further object of the present invention to provide an improved surgical rongeur having an improved button assembly for controlling the displacement of a driving means along the shaft of the rongeur and for controlling the engagement or release of a combined cutting element and storage member, that also functions as a hinge for attaching the handle to the body of the rongeur.

It is another object of the present invention to provide an improved surgical rongeur having an improved means for the rapid engagement and disengagement of a disposable combined cutting element and storage member.

It is yet another object of the present invention to provide a surgical rongeur capable of taking multiple full bites which is activated by a solenoid.

It is still another object of the present invention to provide an electrical rongeur having a battery as a self-contained power source.

It is another object of the present invention to provide a surgical rongeur having a removable shaft portion which can be made in a variety of sizes and configurations and be interchangeably coupled to a manual or power handle means, wherein at least a portion of the removable shaft portion may be disposable.

It is still another object of the present invention to provide a surgical rongeur having a combined cutting element and storage member in communication with a vacuum means for evacuating any contents of the combined cutting element and storage member.

These and other objectives of the present invention shall be more clear upon review of the following detailed description of the drawings when reviewed in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational side view of a surgical rongeur constructed in accordance with the present invention.

FIG. 2 is an exploded first side view of the surgical rongeur of FIG. 1.

FIG. 3 is an exploded second side view of the surgical rongeur of FIG. 1.

FIG. 4 is an exploded view of the surgical rongeur of FIG. 1 showing a bottom plan view of the slide drive member engaged to the cutting/storage member and an elevational second side view of the body.

FIG. 5 is a top plan view along lines 5—5 of FIG. 4 showing the configuration of the slot and recess of the shaft portion of the surgical rongeur of FIG. 1.

FIG. 6 is a cross sectional view along lines 6—6 of FIG. 1 illustrating the cutting/storage member engaged to the shaft of the surgical rongeur of FIG. 1.

FIG. 7 is a partial schematic view of the spring means for biasing the handle of the surgical rongeur of FIG. 1.

FIG. 8 is a perspective view of an alternative embodiment of the cutting/storage member of the surgical rongeur of the present invention comprising a disposable storage and cutting element.

FIGS. 9 is a bottom plan view of a further alternative embodiment of the surgical rongeur of the present invention comprising a disposable combined cutting element and storage member secured to the bottom portion of a carriage member.

FIGS. 10A and 10B are partial elevational side views of alternative embodiments of the foot plate having a groove and the cutting/storage member having an extension element for preventing upward excursion of the cutting/storage member along the foot plate.

FIG. 11 is an elevational and partial sectional side view of an electrically powered surgical rongeur of the present invention.

FIG. 12 is a cross sectional view along lines 12—12 of the electrically powered surgical rongeur of FIG. 11.

FIG. 13 is a cross sectional view along lines 13—13 of the electrically powered surgical rongeur of FIG. 11.

FIG. 14 is a cross sectional view along lines 14—14 of the electrically powered surgical rongeur of FIG. 11.

FIG. 15 is an elevational and partial sectional side view of another alternative embodiment of the electrically powered surgical rongeur of the present invention.

FIG. 16 is a partial elevational and partial sectional side view of another alternative embodiment of the electrically powered surgical rongeur of the present invention.

FIG. 17 is an elevational side view of an alternative embodiment of the surgical rongeur of the present invention.

FIG. 18 is a partial elevational front view along view lines 18—18 of the surgical rongeur of FIG. 17 showing the release button in the engaged position.

FIG. 19 is a partial elevational front view along view lines 18—18 of the surgical rongeur of FIG. 17 showing the release button in the disengaged position.

FIG. 20 is a partial, exploded elevational side view of the surgical rongeur of FIG. 17.

FIG. 21 is a side perspective view of the cutting/storage member of the surgical rongeur of FIG. 17 with the straw member shown in partial cutaway and in the elevated position.

FIG. 22 is a bottom plan view of the cutting/storage member of the surgical rongeur of FIG. 17 with the straw member shown in the lowered position.

FIG. 23 is a cross sectional view along lines 23—23 of FIG. 21 of the straw engagement means of the cutting/

storage member of FIG. 21 shown in the raised position with the lowered position shown in hidden line.

FIG. 24 is a cross sectional view of the cutting/storage member along lines 24—24 of FIG. 22.

FIG. 25 is a cross sectional view along lines 23—23 of FIG. 21 of an alternative embodiment of the straw engagement means shown in the raised position with the lowered position shown in hidden line.

FIG. 26 is a side elevational view of an alternative embodiment of the surgical rongeur of the present invention having a reciprocating shaft terminating in a foot plate and a fixed body portion.

FIG. 27 is a top plan view along lines 5—5 of FIG. 1 showing an alternative embodiment of the surgical rongeur of the present invention having a shaft with a removably attachable end portion.

FIG. 27A is a cross sectional view along lines 27A—27A of FIG. 27 showing the engaging means for removably engaging the end portion to the shaft of the surgical rongeur of FIG. 27.

FIG. 27B is a partial side sectional view of an alternative embodiment of the foot plate having a cutting surface which is out of the plane of the surface of the foot plate facing the cutting edge of the cutting/storage member of the present invention.

FIG. 27C is a partial side sectional view of an alternative embodiment of the foot plate having a cutting surface which is out of the plane of the surface of the foot plate facing the cutting edge of the cutting/storage member of the present invention.

FIG. 28 is a partial elevational side view of an alternative embodiment of the surgical rongeur of the present invention for use in endoscopic surgical procedures.

FIG. 29 is a cross sectional view along lines 29—29 of the endoscopic surgical rongeur of FIG. 28.

FIG. 30 is an exploded elevational side view of an alternative embodiment of the surgical rongeur of the present invention having removably attachable shaft members.

FIG. 31 is a cross sectional view of the engagement means for engaging the removably attachable shaft members of the surgical rongeur of FIG. 30 shown partially inserted.

FIG. 32 is a cross sectional view of the engagement means for engaging the removably attachable shaft members of the surgical rongeur of FIG. 30 shown fully inserted.

FIG. 33 is a partial elevational side view and schematic diagram of an alternative embodiment of the surgical rongeur of the present invention having a vacuum pump in communication with the cutting/storage member for evacuating any contents of the cutting/storage member.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIGS. 1—4, the improved surgical bone rongeur 10 is shown constructed in accordance with the present invention and comprises generally of a body 12 having a rear handle 13 depending at an angle from the proximal end 11 of the body 12, and has a shaft 14 extending distally and terminating at its distal end in a foot plate 16. A support spike 31 extends from the upper portion of the rear handle 13 as support for the area of the hand between the thumb and the first finger. Mounted on the shaft 14 is a slide drive member 20 for reciprocating movement on the shaft 14.

Referring to FIG. 2, a pivoting forward handle 30 includes a lower finger grip portion 34 and an upper finger portion 37

for the fingers. The upper part of the forward handle 30 has an extension 33 with an elongated opening 35 and an aperture 36 through which passes a pivot pin 32. Extension 33 fits into the body 12 through slot 19 (shown in FIG. 5) and is contained within the body 12.

Once the extension 33 is positioned within slot 19, the pivot pin 32, having a screw head 39 on one end and threads at its other end, is used to pivotally attach the forward handle 30 to the body 12. The pivot pin 32 passes through opening 15 in one side of the body 12 through aperture 36 in the forward handle 30 and threads into threaded aperture 17 in the other side of the body 12. The elongated opening 35 of the extension 33 surrounds pin 42 located at the bottom surface of slide drive member 20 which is mounted on the shaft 14 so that the forward handle 30 engages the pin 42 and serves as the driving means for the slide drive member 20. The forward handle 30 is attached to the body 12 at an angle to the slide drive member 20 so that when the forward handle 30 moves proximally the slide drive member 20 moves distally. The forward handle 30 and the rear handle 13 are biased away from each other by spring means 40 and 40a. Spring means 40 is attached at one end to the bottom of forward handle 30 by screw 41 and spring means 40a has one end attached to the bottom of rear handle 13 by screw 43 and may be further secured by having a bend in the end of spring means 40a capable of fitting into an opening of rear handle 13 to prevent rotation of the spring means 40a relative to rear handle 13.

Referring to FIG. 7, in order to interlock the two spring means 40 and 40a, spring means 40 has an extension piece 45 at its upper end that fits into the notch 46 of the upper end of spring means 40a. Once interlocked, the spring means 40 and 40a oppose each other to bias the forward handle 30 distally. Other spring mechanisms, internal or external, and other biasing means, including pneumatic means, may also be employed for urging the forward handle 30 distally.

Referring to FIGS. 4 and 5, the slide drive member 20 is slidably mounted to the top surface of shaft 14 within a slot 24 formed in the shaft 14 having an inverted T-shaped portion 25 into which is fitted a complementary inverted T-shaped runner 26 depending from the bottom surface of slide drive member 20. Slot 24 extends distally from the inverted T-shaped portion 25 to form a wider portion 27 of the slot 24.

Referring to FIG. 4, a stop pin 60 depends from the distal end 61 of the bottom surface of the slide drive member 20. The stop pin 60 serves to guide the slide drive member 20 and to keep the distal end 61 of the slide drive member 20 from sliding off the shaft 14 during the operation of the rongeur 10. The stop pin 60 is set back from the distal end 61 of the slide drive member 20 and fits within the wider portion 27 of slot 24. The wider portion 27 of the slot 24 has a slot wall 28 at its distal end which catches the stop pin 60 and prevents the slide drive member 20 from sliding off the shaft 14 distally.

Referring to FIGS. 2 and 5, on one side of the shaft 14 is a rounded aperture 80. The rounded aperture 80 corresponds in location to a recess 82 in the top surface of shaft 14 as shown in FIG. 5. The recess 82 bisects the wider portion 27 of slot 24 and has a rounded bottom surface. Located within the recess 82 and extending from the aperture 80 is a push button assembly 70 having a large diameter, external button portion 76 and a narrow diameter portion 74 that passes through the aperture 80. The narrow diameter portion 74 has a depression 75 with a flat bottom. The narrow diameter portion 74 terminates at its other end in a large diameter

member 72 having a slightly smaller diameter than the diameter of the rounded recess 82. The large diameter member 72 has a flattened top surface 73 so that it is flush with the top surface of the shaft 14 when the large diameter member 72 is inserted within the recess 82. The reverse end of the large diameter member 72 has a small depression 77 for receiving the end of a coil spring 84 as shown in FIG. 4.

The large diameter member 72 is placed within the recess 82, so that the narrow diameter portion 74 crosses the wider portion 27 of the slot 24 at a right angle and extends through the rounded aperture 80 and the external button portion 76 is external to the shaft 14. The depression 75 in the narrow diameter portion 74 is of a sufficient depth to permit the stop pin 60 depending from the slide drive member 20 to easily pass through the wider portion 27 of the slot 24 and over the depression 75 unobstructed by the narrow diameter portion 74.

Within the recess 82 is a coil spring 84 having an end that fits within the small depression 77 of the large diameter member 72. The coil spring 84 serves to bias the large diameter member 72 so that in its biased position, the large diameter member 72 blocks the wider portion 27 of slot 24. The large diameter member 72 has a diameter that is sufficient to prevent the stop pin 60 from sliding over it. The external button portion 76 is at its greatest extension out of the rounded opening 80 when the large diameter member 72 is in the biased position and blocks the wider portion 27 of the slot 24. To unblock the wider portion 27 of the slot 24, the user simply presses the external button portion 76 of the button assembly 70 so that the coil spring 84 compresses and the large diameter member 72 moves further into the recess 82. When the large diameter member 72 is positioned as far into the recess 82 as possible the depression 75 of the button assembly 70 is positioned directly beneath the stop pin 60 depending from the bottom surface of the slide drive member 20 so that the stop pin 60 can pass through the wider portion 27 of the slot 24 unobstructed.

It is appreciated that the rounded recess 82 may be placed at various locations along the shaft 14 so that the button assembly 70 contained therein may also be positioned at various locations along the shaft 14 beneath the slide drive member 20. The position of the stop pin 60 depending from the slide drive member 20 may also be changed to correspond to the location of the button assembly 70 and the configuration of the slot 24 and the position of the wider portion 27 may also be modified accordingly without departing from the scope of the present invention. For example, the rounded recess 82 may be replaced along the shaft 14 so that it is located within the opening 15 and the threaded aperture 17 of the body 12. In this position, the button assembly 70 in addition to controlling the displacement of the slide drive member 20 along the shaft 14 could also serve as a hinge and attachment means for the forward handle 30 replacing the pivot pin 32 as shown in FIG. 17.

Referring to FIGS. 5 and 6, the shaft 14 has a pair of rails 62,63 extending from either side of the shaft 14 which run parallel to the shaft 14. The rails 62,63 have a bottom substantially flat surface 64 that is perpendicular to the sides of the shaft 14 as shown in FIG. 6. Near the distal end of the shaft 14 are forward notches 65,66 that provide a break in the continuity of the rails 62,63. Positioned proximal to the forward notches 65,66 are rear notches 69,71 which similarly provide a break in the continuity of the rails 62,63.

Referring to FIGS. 4 and 6, the distal end 61 of the slide drive member 20 engages a cutting/storage member 50 which is removably attached to both the shaft 14 and to the

slide drive member 20. The cutting/storage member 50 has depending sides 51 and 52 which are mirror images of each other. As shown in FIG. 4, near the distal end of the cutting/storage member 50, the depending sides 51,52 each have forward rail-engaging members 53,54 respectively. Forward rail-engaging members 53,54 fit within the forward notches 65,66 of shaft 14. Each of the forward rail-engaging members 53,54 has a top substantially flat surface 68 that is perpendicular to the depending sides 51 and 52 for engaging the bottom substantially flat surface 64 of rails 62,63 as shown in FIG. 6. Once the forward rail-engaging members 53,54 are engaged to the rails 62,63, the cutting/storage member 50 is prevented from sliding upward as it moves along the shaft 14.

Also located on each of the depending sides 51,52 of the cutting/storage member 50 are rear rail-engaging members 56,57 which are sufficiently spaced proximally from the forward rail-engaging members 53,54 so that when the forward rail-engaging members 53,54 are placed over forward notches 65,66, the rear rail-engaging members 56,57 are directly over the rear notches 69,71 in the shaft 14. The rear rail-engaging members 56,57 are identical to the forward rail engaging members 53,54 and similarly each have a top substantially flat surface 68 for engaging the bottom substantially flat surface 64 of rails 62,63.

Referring to FIGS. 2 and 4, the proximal end of the cutting/storage member 50 has a male connection means 55 having grooves 58 on both sides of a key portion 59. The male connection means 55 fits into a female connection means 21 located at the distal end 61 of the slide drive member 20. The female connection means 21 has rails 23 for engaging the grooves 58 of the male connection means 55 and a notched area 78 for receiving the key portion 59. The cutting/storage member 50 may be engaged to the slide drive member 20 by lowering the cutting/storage member 50 toward the slide drive member 20 so that the male and female connection means 55 and 21 slide into each other. To disengage the cutting/storage member 50 from the slide drive member 20, the cutting storage member 50 is simply lifted out. As an alternative, the cutting/storage member 50 may also be attached to the slide drive member 20 in any number of conventional ways, such as by snap fit.

The cutting/storage member 50 is placed on the shaft 14 by aligning the forward rail-engaging members 53,54 with the forward notches 65,66 and by simultaneously aligning the rear rail-engaging members 56,57 with the rear notches 69,71 so that the male connection means 55 slides into and engages the female connection means 21 of the slide drive member 20. In order to properly align the cutting/storage member 50 so that it may engage the shaft 14, the slide drive member 20 must be positioned sufficiently proximal from the foot plate 16.

The range of proximal to distal movement of the slide drive member 20 is controlled by the large diameter member 72 of the button assembly 70. In its biased position, the large diameter member 72 is positioned in the wide portion 27 of slot 24 so that the distal edge 79 of the large diameter member 72 blocks the stop pin 60 and thus the slide drive member 20 from moving proximally along shaft 14. The appropriate position of the slide drive member 20 for attaching the cutting/storage member 50 to the shaft 14 may only be achieved by sliding the stop pin 60 past the position of the distal edge 79 of the large diameter member 72. In order to slide the stop pin 60 past the distal edge 79, the button assembly 70 must be manually depressed toward the shaft 14 so that the large diameter member 72 is pushed into the recess 82 and is moved out of the wide portion 27 of slot

24. As the forward handle 30 is biased forward by the spring means 40 and 40a, the slide drive member 20 is moved proximally along the shaft 14 so that the stop pin 60 is positioned within the depression 75 of the narrow diameter portion 74. With the stop pin 60 positioned within the depression 75, the large diameter member 72 is pushed back within the recess and the coil spring 84 is compressed within the recess 82 of the shaft 14.

Once aligned with the forward and rear notches 65,66 and 69,71 and engaged to the slide drive member 20, the cutting/storage member 50 is in position to be pushed distally along shaft 14 by the slide drive member 20 toward the foot plate 16. This is accomplished by squeezing the forward handle 30 to move the slide drive member 20 and the stop pin 60 distally so that the stop pin 60 is no longer within the depression 75 of the narrow diameter portion 74, and the large diameter member 72 is returned to its biased position by the coil spring 84. As the cutting/storage member 50 is engaged to the slide drive member 20, the movement of the cutting/storage member 50 is responsive to the movement of the slide drive member 20. As the cutting storage member 50 is moved distally the front and rear rail-engaging members 53,54 and 56,57 engage the rails 62,63.

Once the cutting/storage member 50 engages the rails 62,63 of the shaft 14, it may not be lifted out and the cutting/storage member 50 is locked to the shaft 14. The proximal movement of the slide drive member 20 is stopped by the large diameter member 72 in its biased position which blocks the stop pin 60 from further proximal travel in the wider portion 27 of the slot 24. To remove the cutting/storage member 50 from the shaft 14, the stop pin 60 must be again positioned by the user so that it is within the depression 75 of the narrow diameter portion 74. Thus, the cutting/storage member 50 may be locked or unlocked to the shaft 14 without the use of tools by simply pressing the button assembly 70. Further, once the button assembly 70 is pushed and the forward handle 34 is advanced by the handle biasing means 40 and 40a, the rongeur 10 remains receptive to the introductions or removal of the cutting/storage member 50 without the need to continue depressing the release button.

Further, the cutting/storage member 50 is secured to the shaft 14 by simply pulling the forward handle 34 securing the cutting/storage member 50 to the shaft 14 until the release button assembly 70 is again depressed. The button assembly 70 does not have to be redepressed to allow pin 60 to move distally as portion 75 is of sufficient length to support it when the slide drive member 20 is maximally proximal.

The cutting/storage member 50 opens into a storage chamber 88 which is bounded by upper and side walls 44 and 85 which are sharpened distally to form cutting edges 22 facing the foot plate 16. The depending sides 51,52 of cutting/storage member 50 are recessed from the foot plate 16 for maximum bite since no cutting edge is required at the depending sides 51,52. While the foot plate 16 may have a slight concave depression to allow for a cutting edge, it is to be understood that it is preferably substantially flat, without a cutting edge.

The storage chamber 88 extends along the interior of the cutting/storage member 50 at least partially toward its proximal end. The cross sectional area of the interior of the storage chamber 88 may be constant or may progressively increase from the distal end to the proximal end so that a number of successive bone fragments can more easily slide into the storage chamber 88 and stack up without jamming.

The rongeur **10** of the present invention is used in the conventional manner to bite bone or cartilage. The cut bone fragments are pushed by the foot plate **16**, one by one, into a stack within the storage chamber **88** of the removable cutting/storage member **50** after being cut and are not likely to fall back into the wound site because they are forced into the storage chamber **88** with considerable force and are prevented from jamming as the cross sectional area of the interior space of the storage chamber **88** either has parallel or divergent walls. Thus, it is not necessary that the cut bone fragments be removed during the surgical procedure, and bite after bite takes place, without the need to remove the rongeur **10** from the wound.

The side walls **44** and **85** of the cutting/storage member **50** have narrow slits **86,87** partially along the length of the cutting/storage member **50**. Once the cutting/storage member **50** is filled with cut pieces of bone, it is removed from the shaft **14** and a stylet or similar instrument may be inserted through the slits **86,87** to aid in the removal of the cut pieces from the storage chamber **88** containing the cut pieces.

Alternatively, the proximal end of the storage chamber **88** of the cutting/storage element **50** may also be open. During use, the distal end **61** of the slide drive member **20** may be used to block the open proximal end of the storage chamber **88**. Once the cutting/storage member **50** is removed from the rongeur **10**, the proximal end of the storage chamber **88** is open and a stylet may be used to push the cut bone fragments stored within the storage chamber **88** so that the fragments exit from the distal end or in reverse from the proximal end.

The use of a removable hollow cutting/storage member **50** permits a new sharp cutting edge to be provided for each operation as it may easily be replaced. Both the storage chamber **88** and the cutting edge **22** could be made of metal or any other suitable material such as, but not limited to, ceramic for the cutting edge **22** or a plastic (e.g. polycarbonate) for the storage chamber **88**.

In the preferred embodiment, the rongeur **10** has a body **12** that is approximately $7\frac{1}{4}$ inches in length; a cutting/storage member **50** that is approximately $3\frac{1}{4}$ inches in length and approximately $\frac{7}{8}$ inches in height and approximately $\frac{3}{8}$ inches in width; a slide drive member **20** that is approximately $3\frac{3}{16}$ inches in length and approximately $\frac{7}{16}$ inches in height and approximately $\frac{3}{8}$ inches in width; a rear handle **13** approximately $4\frac{7}{8}$ inches in length and a front handle **30** approximately $4\frac{3}{8}$ inches in length having an extension member **33** that is approximately $\frac{7}{8}$ inches long; and a button assembly **70** having an overall length of approximately $\frac{7}{16}$ inches.

It is appreciated that the cutting elements of the rongeur of the present invention need to be made of a material capable of forming a sharp cutting edge and serving the intended purpose of the rongeur. Such materials include, but are not limited to, metals, ceramics or composite materials. The remainder of the rongeur could be made of metal, plastic or a composite material suitable for the intended purpose, such that the entire rongeur could be disposable.

Referring to FIGS. **8** and **9**, in a first alternative embodiment of the present invention, the rongeur **10** includes a removable and disposable straw **90** that is attachable to the bottom of a carriage member **96**. The carriage member **96** is similar in construction to the cutting/storage member **50** but does not have the storage chamber **88** and essentially acts as a housing for carrying the straw **90**. Straw **90** is a hollow member in the shape of a cylinder or may have any other shape suitable for use with rongeur **10**. At the distal end of

the straw **90** is a sharp cutting edge **92** for cutting bone or other similar tissue. In this embodiment, the cutting/storage member **50** is actually a carrier member as the straw **90** does the actual cutting and storing of the bone. Prior to use, the straw **90** is inserted within the storage chamber **88** before the cutting/storage member **50** is placed on the shaft **14**. The hollow chamber **94** of the straw **90** functions to store the cut pieces of bone or cartilage. The stored cut pieces may be removed for future use in the same manner described above for the preferred embodiment.

The straw **90** is placed in the bottom of the carriage member **96** prior to placing the carriage member **96** on the shaft **14**. The straw **90** is held in place and is prevented from rotating by pins **97,98** which complement the grooves **101, 102** in the straw **90** as shown in FIG. **9**, and prevent any movement of the straw **90** within the carriage member **96** during the operation of the rongeur. Once the carriage member **96** is removed from the shaft **14**, the straw **90** is easily removable from the carriage member **96**.

The straw **90** is preferably made of metal or any other material which is capable of being sharpened and maintaining a sharp cutting edge **92** for multiple bites by the rongeur **10**. After the straw **90** is used and removed from the rongeur **10**, the cut pieces contained therein are removed and may be used for bone grafting purposes if desired. The relatively low cost of the straw **90** allows the straw **90** to be truly disposable.

Referring to FIGS. **10A** and **10B**, a second alternative embodiment of the rongeur **10** is shown with the intersection of the foot plate **16** and the shaft **14** having a groove **29** such that the distal end of the cutting/storage member **50** or of a straw **90** has an extension element **38** that complements the shape of the groove **29** and fits within the groove **29**. The extension element **38** may be made of the same material as the cutting/storage member **50**. As a result of the angled orientation of the foot plate **16**, when the rongeur is fully closed, the cutting/storage member **50** or the straw **90** tends to be forced up the inclination of the foot plate **16** which may result in damage to the cutting edge **22** or **92**. The combination of the groove **29** and the extension element **38** functions to prevent any upward excursion of the cutting/storage member **50** or straw **90** which would result in an overbite.

The operation of the rongeur **10** of the present invention is as follows:

The rongeur **10** is set in the "release position" by positioning the stop pin **60** within the depression **75** of the narrow diameter portion **74** of the button assembly **70**. This is accomplished by manually pressing the external button portion **76** of the button assembly **70** so that the large diameter member **72** moves out of the wider portion **27** of the slot **24** to compress the coil spring **84**. The stop pin **60** may now freely pass by the position of the distal edge **79** of the large diameter member **72** and to fit within the depression **75**. As the spring means **40** and **40a** bias the forward handle **30** distally, the slide drive member **20** moves toward the foot plate **16**. With the stop pin **60** positioned within the depression **75**, the coil spring **84** is kept compressed within the recess **82**.

In the release position, the slide drive member **20** is positioned so that the cutting/storage member **50** may be easily placed on the shaft **14**. In the release position, the forward rail-engaging members **53,54** are aligned with the forward notches **65,66** and the rear rail-engaging members **56,57** are aligned with the rear notches **69,71**. Once aligned, the cutting/storage member **50** is positioned to easily engage

the slide drive member **20** so that the male and female connector means **55** and **21** mate and the cutting/storage member **50** rests upon the shaft **14**.

Once the cutting/storage member **50** is engaged to the slide drive member **20**, the forward handle **30** is squeezed by the user to advance the slide drive member **20** so that the stop pin **60** exits from within the depression **75** and the large diameter member **72** is returned by the coil spring **84** to its biased position to block the wider portion **27** of the slot **24**. With the large diameter member **72** in this position, the stop pin **60** is stopped from any further proximal movement past the distal edge **79** of the large diameter member **72** thereby preventing any further proximal movement of the slide drive member **20** past the large diameter member **72**. With the slide drive member **20** in this position, the forward and rear rail engaging members **53,54** and **56,57** are engaged to the rails **62,63** and are no longer aligned with the forward and rear notches **65,66** and **69,71**. Therefore, the cutting/storage member **50** is securely locked to the shaft **14** and may not be removed from the shaft **14**.

With the cutting/storage member **50** in the locked position on the shaft **14**, the rongeur **10** may be placed in the wound and used to take multiple bites or cuts of the selected tissue with the cut pieces being stored within the storage chamber **88** of the cutting/storage member **50**. Once the desired number of bites has been attained or if the storage chamber **88** becomes filled, the rongeur **10** is removed from the wound. The cutting/storage member **50** is removed from the shaft **14** of the rongeur by returning the rongeur to the release position by pressing the external button portion **76** as described above, so that the forward and rear rail-engaging members **52,54** and **56,57** are once again aligned with the forward and rear notches **65,66** and **69,71** and no longer engage the rails **62,63**. The cutting/storage member **50** is then easily lifted up and away from the shaft **14**.

The cut pieces may be removed from the storage chamber **88** by inserting a stylet in the slits **86,87** in the side walls **44,45** of the cutting/storage member **50** and pushing the cut pieces out from the chamber. If an alternative embodiment of the cutting/storage element **50** is used where the proximal end of the storage chamber **88** is closed only during use, the cut pieces may be pushed out of either end of the storage chamber **88**. Similarly, if a disposable straw **90** is used, the cut pieces contained within the straw **90** may be removed by using a stylet to the push the cut pieces out of either the proximal or the distal end of the straw **90** which are both open when not in use.

Further, the improved surgical rongeur of the present invention may be powered by alternative power sources such as electricity, via a cord or battery supply, pneumatic power, or other power sources can be employed. In a powered rongeur, the finger grip of the rongeur can then be devoted to turning on and off the power supply source to drive the instrument. If gas or other fluid is used, a pressure relief valve is preferably incorporated within the fluid line to establish a limit pressure, which may be set to the maximum desired biting force to be delivered.

Referring to FIG. **11**, an electrically powered rongeur **200** is shown. The rongeur **200** comprises a housing **201** having a grip **202** that is adapted for receiving a rechargeable battery pack **204** and related electronic circuitry **206**. The battery pack **204** is removably inserted into the grip **202** through an opening at the base of the grip **202** and has spring clips **207** on either side of the battery pack **204** which fit into corresponding openings **208** in the grip **202** and lock into place. The battery pack **204** is removed by depressing the

spring clips **207** so that they are out of the openings **208** and the battery pack **204** is easily removed from within the grip **202**. It is appreciated that in a simple variation of this embodiment, the battery pack **204** itself may serve as a removably attachable handle instead of fitting within the grip **202**. In this manner the battery pack **204** may be easily replaced by the surgeon.

The battery pack **204** has contacts **209** for electrical coupling to an activation switch **210**. The activation switch **210** is operated by the depression of a trigger **212** and is electrically coupled to the electronic circuitry **206** via contacts **209**. The activation switch **210** is used for controlling the power supplied to a solenoid **214** located above the grip **202** and within the housing **201**. The solenoid **214** is electrically coupled to the electronic circuitry by contacts **209**. The rear portion of the housing **201** can be opened for access to the compartment by the removal of cap **216** which is threadably attached to the housing **201**. Prior to sterilization, the cap **216** and the solenoid **214** can be removed from the housing **201**. The rongeur **200** can be sterilized. It is appreciated that all of the electrical components of the electrical rongeur **200** may have contacts **209** such that the electrical components may be easily removed and replaced without the need for wiring these components.

The solenoid **214** drives a reciprocating rod **218** which is removably coupled at its distal end **220** to a cutting/storage member **222** and terminates in a proximal end portion **224**. The proximal end portion **224** is made of a non-ferrous material, such that the proximal end portion **224** is not affected by the electromagnetic field generated by the solenoid **214**. The rod **218** is spring biased by a strong spring **226** in the proximal direction to maintain the rod **218** in a maximally, proximal position and thus maintain a gap between the foot plate **16** and the cutting edge **22** of the cutting/storage member **222**. Near the proximal end portion **224** of the rod **218** is a plunger **228** having a bore **230** for receiving at least a portion of the proximal end portion **224**. The plunger **228** is made of a ferrous material such that the plunger **228** is responsive to the electromagnetic field generated by the solenoid **210**. When the solenoid **210** is powered, the plunger **228** is driven forward in the distal direction, driving the rod **218** in the same direction toward the foot plate **16** such that the cutting edge **22** of the cutting/storage member **222** contacts the foot plate **16**. The rod **218** is then returned to its proximal position by the spring **226**. The proximal travel of the plunger **228** is stopped by stopper **232** made of a resilient and sterilizable material such as an appropriate plastic well known by those skilled in the art.

As a safety precaution, the momentum at which the rod **218** is driven forward toward the foot plate **16** may be set to a desired rate, such that excessive force is not exerted on the cutting edge **22** and the foot plate **16**. Further, the rod **218** can be adjustable along the longitudinal axis, either by threads or other means, such that a precise closing of the cutting edge **22** against the foot plate **16** is achieved. In this manner, any other tendency of the cutting edge **22** to continue distally placing further stress on the foot plate **16** is avoided.

The depression of the trigger **212** closes the switch **210** to cause one closing and opening of the rongeur **200**. For a second closing operation, the trigger **212** must be released and then depressed again in order to close switch **210** once again. A safety mechanism for preventing activation of the switch **210**, well known in electrically operated devices, can be included. Such a safety mechanism could consist of a mechanical interference between the trigger and the switch

to prevent activation of the switch **210** or a second trigger may be placed in a separate location on the grip **202** to insure that activation of the rongeur occurs only when both the trigger **212** and the second trigger are depressed to avoid accidental activation of the rongeur **200**.

Referring to FIGS. 11–14, the cutting/storage member **222** is a hollow tube for containing multiple cut pieces of bone or cartilage, having a sharp cutting edge **22** and an engagement end **234** for removably engaging the rod **218**. The cutting/storage member **222** is slidable within a shaft housing **236** which remains stationary as the cutting/storage member **222** reciprocates along the shaft **238** in rectilinear motion. Although the shaft housing **236** has been described and shown as being a single piece, it is appreciated that shaft housing **236** may comprise a number of separate pieces spaced apart along the shaft **238** while still being capable of housing the cutting/storage member **222**. Engagement end **234** is closed when in use, but once the cutting/storage member **222** is removed from within the shaft housing **236**, it is open such that bone may be pushed from one end of the cutting/storage member **222** out the other end with the use of an obdurator or other similar instrument.

The shaft housing **236** removably engages the shaft **238** in the same manner in which the cutting/storage member **50** (described above) removable attaches to shaft **14** as described in detail above. Like the cutting/storage member **50**, the shaft housing **236** has forward rail-engaging members **53,54** which fit within the forward notches **65,66** of shaft **238** and rear rail-engaging members **56,57** which are sufficiently spaced proximally from the forward rail-engaging members **53,54** so that when the forward rail-engaging members **53,54** are placed over forward notches **65,66**, the rear rail-engaging members **56,57** are directly over the rear notches **69,71** in the shaft **238**. The shaft housing **236** is then slid in the distal direction toward foot plate **16**, such that the forward rail-engaging members **53,54** and the rear rail engaging members become engaged to the rails **62,63**, and the shaft cover **236** is prevented from sliding upward and becomes locked to the shaft **238**.

Referring still to FIG. 11, to ensure that shaft cover **236** stays locked to the shaft **238**, a biasing spring **240** is located within the housing **201** and maintains the shaft housing **236** biased in a maximal distal position. During the removal of the shaft housing **236**, the shaft housing **236** is moved proximally to compress the biasing spring **240** and permit the shaft housing **236** to become disengaged from the shaft **238**.

Referring to FIG. 14, a top plan view of the connections between the cutting/storage member **222** and the rod **218** is shown. The engagement end **234** of the cutting/storage member **222** has a female connection means **242** comprising radiused portions **244a** and **244b** on both sides such that a corresponding male connection means **246** on the rod **218** fits into the female connection means **242**. The cutting/storage member **222** may be engaged to the rod **218** by removing the shaft housing **236** and then lowering the cutting/storage member **222** onto the shaft **238** so that the female and male connection means **242** and **246**, respectively, engage. The shaft housing **236** is then replaced and locked to the shaft **238** as described above. To disengage the cutting/storage member **222** from the rod **218**, the shaft housing **236** is disengaged from the shaft **238** by sliding the shaft housing **236** in the proximal direction to compress the biasing spring **240**, the shaft housing **236** is lifted off, and then the cutting/storage member **222** is easily lifted out.

In use, the surgeon would insert the rongeur **200** around the bone to be cut and the trigger **212** would be pulled. The

pulling of the trigger **212** would cause the rod **218** and the cutting/storage member **222** to be driven forward to close against the foot plate **16** cutting the bone and the cutting/storage member **222** and the foot plate **16** are returned to their original open position regardless of the trigger **212** being released or left depressed. This occurs because the delivery of electrical current to the solenoid **214** is interrupted by the electronic circuitry **206** and the strong return spring **226** returns the cutting/storage member **222** and the foot plate **16** to their original open position. Releasing the trigger **212** would permit the cutting/storage member **222** to return to its open position. The surgeon would then move the rongeur **200**, without removing the rongeur **200** from the wound, to the next area of bone requiring biting, and again activate the trigger **212** and cause the rongeur **200** to close. The power rongeur **200** may be modified for use with any of the cutting/storage members described herein, such as the first embodiment described above in reference to FIG. 1.

Referring to FIG. 15, rongeur **200a** is shown which is an alternative embodiment of rongeur **200**. In this embodiment, rongeur **200a** has a reciprocal rod **218a** coupled to the slide drive member **20** by a resilient compressible member **221** described in detail in copending application Ser. No. 07/398,987 filed on Aug. 28, 1989 incorporated by reference herein. The function of the rongeur **200a** is the same as described above for rongeur **10**, except that it is powered electrically. It is also appreciated that any of the embodiments of the rongeur of the present invention may be similarly adapted to become electrically powered without departing from the scope of the present invention.

The rod **218a** has a non-ferrous portion **260**, a ferrous portion **262**, and terminates proximally in a threaded end portion **264**. Threadably attached to the threaded end portion **264** is a disc **266** which functions to stop the distal travel of the rod **218a** as it is advanced through the solenoid **214** by making physical contact with the solenoid **214**. As the disc **266** is threadably attached to the threaded end portion **264**, the distal travel of the rod **218a** may be regulated by varying how far the threaded end portion **264** is threaded into the disc **266** resulting in a change in the length of the rod **218a** passing through the solenoid **214**. To shorten the distance of the distal travel by the rod **218a**, the threaded end portion **264** is threaded further into the disc **266**. If a greater distance of travel of the rod **218a** is desired, the disc **266** is unscrewed such that less of the threaded end portion **264** is threaded into the disc **266**. In this manner, the force generated by the activation of the solenoid **214** is may be adjusted by varying the length of the rod **218a** passing through the solenoid **214**.

Referring to FIG. 16, an alternative embodiment of the power rongeur of the present invention is shown and generally referred to by the numeral **300**. The rongeur **300** comprises a primary solenoid **302**, a plunger **304**, a smaller secondary solenoid **306**, electronic circuitry **307** and a reciprocating rod **308**. The primary solenoid **302**, the secondary solenoid **306** and the electronic circuitry **307** are electrically coupled via contacts **309** to facilitate removal and replacement of those components without having to detach and reattach any wires. The reciprocating rod **308** has a proximal end comprising a first nonferrous portion **310**, a ferrous portion **312**, and a second nonferrous portion **314**. The secondary solenoid **306** is much smaller and less powerful than the primary solenoid **302**. When the secondary solenoid **306** is activated, the electromagnetic field created urges the reciprocating rod **308** in the distal direction such that the ferrous portion **312** moves distally within the electromagnetic field of the secondary solenoid **306**. In this position, the reciprocating rod **308** is positioned in a distal

direction sufficient to place the cutting edge 22 of the cutting/storage element 236 (shown in FIG. 11) in contact with the bone to be cut. It is important to note that the purpose of the secondary solenoid 306 is merely to advance the reciprocating rod 308 a sufficient distance to bring the cutting edge 22 in contact with the bone to be cut, but not to cut the bone.

Once the cutting edge 22 is properly positioned at the site in which a cut is desired through the activation of the secondary solenoid 306, the primary solenoid 302 is activated and the plunger 304 is driven in the distal direction to provide a high impact force to the reciprocating rod 308 and the desired cut is performed. At that point in time, the delivery of electrical current to the primary solenoid 302 and the secondary solenoid 304 stops and the reciprocating rod 308 is then returned to its maximal proximal position by the biasing spring 240 regardless of whether the trigger 212 is released or left depressed. The plunger 304 is returned to its starting position by the spring 313 which is coupled to the removable cap 315.

The supply of electrical current to the primary solenoid 302 and secondary solenoid 306 is controlled by a trigger 316 which closes an activation switch 318 having two stages. In the first stage, the trigger 316 is only partially depressed, such that the activation switch 318 delivers electrical current only to the secondary solenoid 306 for positioning the cutting edge 22 against the bone to be cut. The delivery of electrical current to the secondary solenoid 306 ceases immediately upon the release of the trigger 316 permitting the surgeon to reposition the rongeur 300 prior to cutting the bone. In the second stage, the trigger 316 is fully depressed such that the activation switch 318 delivers electrical current to the primary solenoid 302 while continuing to deliver electrical current to the secondary solenoid 306.

The full depression of the trigger 316 causes one closing and opening of the rongeur 300. For a second closing operation, the trigger 316 must be released and then depressed again in order to close switch 210 once again. It is appreciated that the first stage activation of the secondary solenoid 306 may be bypassed if a surgeon desires to make an immediate cut without first positioning the cutting edge 22 against the bone by fully depressing the trigger 316 at once to power the primary solenoid 302.

Further, the electrical rongeur 300 may include a force adjusting means for adjusting the cutting force of the rongeur 300. In one embodiment, such a force adjusting means may include an angled threaded opening 350 in the housing 301 for receiving a threaded member 352 therein. The threaded member 352 is threaded into the opening 350 such that the head 354 of the threaded member 350 sufficiently extends to limit the distal motion of the rod 308 by making contact with the oversized portion 356 of the rod 308. It is appreciated that the further the threaded member 352 is threaded into the opening 350 the greater the limitation of the distal motion of the rod 308 and thus the lesser is the cutting force. It is further appreciated that the cutting force of the rongeur 300 can be limited electronically by controlling the amount of current that is delivered to the primary solenoid 302. Such an electronic means is well known by those skilled in the art.

Referring to FIGS. 17-25, an alternative embodiment of a surgical rongeur made in accordance with the present invention is shown and generally referred to by the numeral 400. The rongeur 400 is similar in structure to the rongeur 10 in the embodiment described above, except that it has an improved button assembly 420 and an improved cutting/storage member 430.

Referring specifically to FIG. 17, the improved button assembly 420 functions to control the displacement of the slide drive member 20 along the shaft 14 in order to release or to engage the cutting/storage member 430 from the shaft 14 as described above. The improved button assembly 420 is located near the proximal end 11 of the shaft 14 and fits in the opening 15 to replace the pivot pin 32. In this manner, the improved button assembly 420 also serves as a pivot pin and attachment means for front handle 30.

Referring to FIG. 20, the improved button assembly 420 comprises a button member 422 having a large diameter portion 424 and a narrow diameter portion 426 with a threaded end 427. The narrow diameter portion 426 fits through a hollow sleeve member 428 and threads to a substantially flat member 440 having a threaded opening 441 and is located on the opposite side of the body 12 of the rongeur 400. The hollow sleeve member 428 acts as a bushing about which the front handle 30 pivots during the operation of the rongeur 400. Between the button member 422 and the substantially flat member 440 is a coiled spring 442 that maintains the button member 422 in a biased position.

Referring to FIGS. 18 and 19, a front elevational view along lines 18-18 of FIG. 17 of the button assembly 420 in the biased position is shown. The substantially flat member 440 has an extension pin 446 that functions to limit the travel of the slide drive member 20 towards the proximal end 11 of the shaft 14. In the biased position, the extension pin 446 is positioned such that it is between the top part 448 of the forward handle 30 and the body 12 to create space S so as to keep the slide drive member 20 in a more distal position. In this manner, the cutting/storage member 430 is engaged to the shaft 14 and is in the locked position as discussed above for the preferred embodiment of the surgical rongeur 10.

Referring to FIG. 19, a front elevational view along lines 18-18 of the button assembly 420 is shown in the unbiased position that is achieved when the button assembly 420 is depressed in the direction indicated by arrow A. The top part 448 of the front handle 30 has a notch 450 capable of receiving at least a portion of the extension pin 446 when the button assembly 420 is in the unbiased position. In the unbiased position, the extension pin 446 no longer keeps the top part 448 of the forward handle 30 away from the body 12 of the rongeur 400 such that space S is eliminated and the slide drive member 20 is moved in a more proximal direction which allows the cutting/storage member 430 to be disengaged and removed from the shaft 14. When the extension pin 446 is in the notch 450, the button assembly 420 is prevented from returning to its normal biased position because the wall 452 of the notch 450 prevents the travel of the extension pin 446 in that direction.

When the front handle 30 is squeezed by the surgeon, the front handle 30 moves in the direction of the rear handle 13 and away from the body 12 of the rongeur 400 creating the space S between the top part 448 of the front handle 30 and the body 12. In this position, the extension pin 446 is no longer contained within the notch 450 and moves, as result of the force of the coiled spring 454, into the space S that is created between the top part 448 of the forward handle 30 and the body 12 of the rongeur 400. Once the front handle 30 is released by the surgeon, the top part 448 of the front handle 30 rests against the extension pin 446 and is kept at a distance from the body 12 that is equal to the diameter of the extension pin 446. As a result, the rongeur 400 is self-locking simply by the squeezing of the front handle 30.

Referring to FIGS. 21 and 22, the improved cutting/storage member 430 is shown comprising a removable and

disposable straw **460** which is a hollow member that is similar in structure to the straw **90** as described above. The distal end of the straw **460** is a sharp cutting edge **462** for cutting bone or other similar tissue. The straw **460** is affixed to the bottom of a slideable shaft housing **470** which is similar in construction to the carriage member **96** described above but has a straw engagement means **472** for removably engaging the straw **460** to the modified cutting/storage base **470**.

Referring to FIG. 23, an enlarged cross sectional view of the straw engagement means **472** is shown comprising a pivoting member **474** and a detent means **476**. The detent means **476** comprises a housing **478** for containing a spring means **480** for spring loading a detent ball **482**. A first end **484** of the pivoting member **474** is connected to the detent ball **482** and is maintained by the detent means **476** in a raised position or in a lowered position as shown in broken lines in FIG. 23. A second end **486** of the pivoting member **474** is capable of receiving the proximal end of the straw **460** and has a lip **485** so that the pivoting member **474** may be lifted to the raised position in the absence of a straw **460** in order to permit engagement of the straw **460** to the pivoting member **474**.

Referring to FIG. 24, a cross sectional view of the cutting/storage member **430** along lines 24—24 of FIG. 22 is shown. Extending from the second end **486** of the pivoting member **474** is a stabilizer pin **488** which fits into a corresponding opening **490** located near the proximal end of the straw **460** and functions to stabilize the straw **460** once the pivoting member **474** is inserted within the second end **486** of the straw **460**. The stabilizer pin **488** prevents rotational movement and distal movement of the straw **460** during the operation of the rongeur **400**.

Referring back to FIG. 21, the straw engagement means **472** functions to facilitate the attachment and the removal of the straw **460** to the shaft housing **470**. Prior to use, the straw **460** is placed in the shaft housing **470** so that it engages the pivoting member **474** in the raised position prior to placing the shaft housing **470** on the shaft **14**. Once the straw **460** is engaged to the straw engagement means **472**, the straw **460** is lowered towards the shaft housing **470** such that the straw **460** wedges into converging trapezoidal walls **473A** and **473B** and the detent means **476** keeps the straw **460** pressed into a stable wedged position, and prevents any movement of the straw **460** within the shaft housing **470** during the operation of the rongeur **400**.

To remove the straw **460**, once the shaft housing **470** is removed from the shaft **14**, the straw **460** is lifted away from the shaft housing **470** such that the pivoting member **474** is returned to its raised position. The surgeon then simply pulls the straw **460** away from the pivoting member **474** and engages a new straw **460** to the pivoting member **474**. The bone contained within the first straw **460** may then be harvested and the first straw **460** may then be disposed.

Referring to FIG. 25, an alternative embodiment of the straw engagement means **500** having a pivoting member **510** that pivots about an axis **520** and has a first end **522** with notches **524a** and **524b** each capable of receiving at least a portion of the detent ball **530** therein. The pivoting member **510** has the same function as the pivoting member **474** described above, and the notches **524a** and **524b** function to maintain the pivoting member **510** in the lowered or raised position, as described above for the straw engagement means **472**. As the pivoting member **570** pivots about the axis **520**, the detent ball **530** engages one of the notches **524a** or **524b** to hold the pivoting member **570** in a raised or

lowered position. The pivoting member **570** has an extension pin **588** that has the same structure and function as the extension pin **488** described above and a lip **585** that has the same structure and function as the lip **485** described above.

Referring to FIG. 26, an alternative embodiment of the present invention is shown and generally referred to by the numeral **600**. The rongeur **600** comprises of a body **610** having a rear handle **612** depending at an angle from the proximal end **614** of the body **610**, and has an upper body portion **616** terminating into a removable cutting/storage element **50**. The upper body portion **616** is fixed and is capable of housing and slideably receiving a reciprocating shaft **618** which terminates in a foot plate **16**. The reciprocating shaft **618** is driven by a front handle **620** which is pivotably attached to the body **610**. The front handle **620** drives the reciprocating shaft **618** via a toothed gear **622** which engages a correspondingly toothed track **624** of the reciprocating shaft **618** while the body **610** remains stationary. In this embodiment, the cutting/storage element **50** remains in a fixed position while the shaft **618** reciprocates during the cutting action of the rongeur **600** to bring the foot plate **16** into contact with the cutting/storage member **50**.

Referring to FIG. 27, an alternative embodiment of the surgical rongeur of the present invention is shown and generally referred to by the numeral **700**. The rongeur **700** comprises a body **712** having a shaft **714** extending distally with a removable portion **715**. The removable portion **715** has its distal end terminating in a foot plate **716** and its proximal end having a double-key, male member **718** for engaging a corresponding female member **720** located at the distal end of the shaft **714**.

Referring to FIG. 27A, the male member **718** is shown fully seated within the female member **720** to provide a stable coupling capable of enduring the above-described forces encountered during the operation of the rongeur **700**. The removable portion **715** provides the added advantage of allowing the surgeon to easily replace at least a portion of the shaft **714**, such as the foot plate **716**, along with replacing the cutting/storage member if desired, as described in detail for the embodiments set forth above.

It is appreciated that an important advantage of the removable portion **715** is that multiple removable portions **715** of various sizes and lengths having various foot plates **716** can be made available to the surgeon appropriate for the particular surgical procedure being performed by the surgeon. In this manner the versatility of the rongeur **700** is greatly increased, the need for having multiple rongeurs of different sizes and configurations is eliminated greatly reducing cost, especially if the rongeur **700** is power actuated.

For example, the removable portion **715** may have a foot plate **716** that is angled relative to the shaft **716** in a specific orientation for a particular surgical procedure such that a number customized removable portions **715** may be provided for use with a common body, handle and shaft **714**. The removable portion **715** may have different lengths, diameters and the overall configuration of the removable portion **715** may be rounded for use in endoscopic procedures as described in reference to FIGS. 28 and 29 set forth in detail below.

Further, the structure of the rongeur **700** allows for a variety of different sizes and configurations of removable portion **715** and foot plate **716** to be interchangeably utilized with a common handle, body, and shaft **714**. Additionally, the structure of the rongeur **700** allows for the replacement of both cutting edges—the cutting/storage member and the

foot plate **716**—when it is desired to incorporate a cutting surface that is out of the plane of the surface **730** on the foot plate **716** sufficient to provide a cutting surface but not to hold a substantial amount of bone such that it would prevent the bone from being advanced into the cutting/storage member. When the foot plate **716** contains such a cutting surface, it is preferable that the entire removable portion **715** be disposable such that fresh, sharp cutting surfaces are provided with each use.

Referring to FIG. 27B, a partial side sectional view of an alternative embodiment of the rongeur **700** having a foot plate **716a** with a cutting surface **740** which is out of the plane of the surface **730** of the foot plate **716a** facing the cutting edge **742** of the cutting/storage member **750** is shown. The cutting surface **740** is slightly raised from the surface **730** such that the cutting surface **730** and the cutting edge **742** contact and mate during the cutting of bone or cartilage. The cutting edge **742** is preferably sharpened only on the interior side **754** of the cutting/storage member **750**.

Referring to FIG. 27C, an alternative embodiment of the foot plate **716a** of FIG. 27B is shown and generally referred to by the numeral **716b**. The foot plate **716b** has a cutting surface **740a** which is out of the plane of the surface **730** facing the cutting edge **742a** of the cutting/storage member **752**. In this embodiment, the cutting surface **740a** is below the plane of the surface **730** such that the cutting edge **742a** of the cutting/storage member **752** is received within the cutting surface **740a**. The cutting edge **742a** is preferably sharpened on both the interior side **754** and the exterior side **756** such that the cutting edge **742a** is a knife-like edge.

Referring to FIGS. 28 and 29, an alternative embodiment of the surgical rongeur of the present invention for use in endoscopic surgical procedures is shown and generally referred to by the numeral **800**. The endoscopic rongeur **800** has a shaft **814** and a cutting/storage member **850** that are preferably rounded over their entire length, but may be more limitedly rounded in a particular area such as the area of the shaft and handle junction. The cutting/storage member **850** preferably has a straw **890** similar to the straw **90** described above in reference to FIGS. 8 and 9, and having a semi-circular cross section to maximize the biting and storage area of the endoscopic rongeur **800**. Such an overall rounded configuration facilitates the passage of the endoscopic rongeur **800** through the skin and flesh or as more commonly practiced through a cannula typically used for such endoscopic surgery to pass through the skin and soft tissue of the patient and into the abdomen, thorax, or within other areas of the body while still allowing for a good seal against gas or fluid leakage from within the body of the patient.

Referring specifically to FIG. 29, a cross sectional view of the endoscopic rongeur **800** is shown illustrating the overall circular diameter of the shaft **814** and cutting/storage member **850**. It is appreciated that in order to better form a seal with the opening in the body of the patient, the cutting/storage member **850** may be slideable within a fixed exterior housing, such as shaft housing **236**, described above for the embodiment shown in FIGS. 11–14. Such an exterior housing would also have an overall circular diameter. In this manner, once the endoscopic rongeur **800** is placed within the opening in the body, the seal formed between the fixed exterior housing and the opening of the patient is maintained relatively undisturbed.

The endoscopic rongeur **800** preferably has an overall length of approximately 13.0 inches (330.2 mm) to 18.0 inches (457.2 mm), with a shaft length measured from the foot plate to the handle of approximately 10.5 inches (266.7

mm) to 13.0 inches (330.2 mm), and a shaft diameter of approximately $\frac{3}{16}$ inches (4.0 mm) to $\frac{1}{2}$ inch (12.0 mm) and preferably $\frac{1}{8}$ inch (8.0 mm).

It is appreciated that the endoscopic rongeur **800** can be activated manually by rear handle **13** and forward handle **30** described above, having an overall length of approximately 3.5 inches (88.9 mm) to 6.0 inches (152.4 mm). It is further appreciated that the endoscopic rongeur **800** may be power actuated by any of the power means described above in reference to FIGS. 11–16.

Referring to FIGS. 30–32, an alternative embodiment of the surgical rongeur of the present invention is shown and generally referred to by the numeral **900**. The rongeur **900** comprises a removable unit **902** which removably engages a body **912**. The removable unit **902** comprises a shaft **914** terminating in a foot plate **916** and a cutting/storage member **950**. The removable unit **902** has a pair of engagement members **920** and **922** which are identical and fit into corresponding slots **924** and **924** in the body **912**. Each of the engagement members **920** and **922** comprise a flexible upper tyne **930** and a flexible lower tyne **932** sufficiently spaced apart to permit the upper and lower tynes **930** and **932** to flex toward each other.

Near the proximal end of the engagement members **920** and **922**, each of the upper and lower tynes **930** and **932** have protuberances **934a** and **934b** on the external surfaces and radiused portions **936a** and **936b** on the interior surfaces to form a substantially circular recess **938**. The protuberances **936a** and **936b** fit into corresponding notches **940a** and **940b** formed in slot **924**.

Referring specifically to FIG. 31, engagement member **920** is shown being partially inserted into slot **924** with the upper and lower tynes **930** and **932** being flexed toward each other as a result of the protuberances **934a** and **934b** contacting the walls of the slot **924**. Located at the end of the slot **924** is a detent means **942** comprising a barrel member **946** connected via shaft **948** to a tab member **952** situated within an opening **956** in the body **912** proximate the slot **924**. The detent means **942** is biased distally by spring **954** such that when the proximal ends of the upper and lower tynes **930** and **932** contact the barrel member **946**, the spring **956** compresses to permit the upper and lower tynes **930** and **932** to be further inserted into the slot **924** until the protuberances **934a** and **934b** coincide in position with the notches **940a** and **940b** respectively. As the protuberances **934a** and **934b** are entering the notches **940a** and **940b**, respectively, the barrel member **946** forces apart the upper and lower tynes **930** and **932**, and the spring **956** biases the barrel member **946** distally into the recess **938**.

Referring to FIG. 32, engagement member **920** is shown fully inserted and seated within the slot **924** with the protuberances **934a** and **934b** fully seated within the notches **940a** and **940b**, respectively, and the barrel member **946** is fitted within the recess **938** to maintain the appropriate spacing between the upper and lower tynes **930** and **932** such that the protuberances **934a** and **934b** remain fully seated within the notches **940a** and **940b**, respectively, and the removable unit **902** is locked into place to the body **912** and can not be removed unless it is unlocked by the surgeon. The removable unit **902** remains locked to the body **912** for as long as the barrel member **946** is situated within the recess **938**.

To unlock the removable unit **902** from the body **912**, the tabs **952** for each of the engagement members **920** and **922** are moved in the proximal direction by the surgeon such that the barrel member **946** is removed from within the recess

938 and the upper and lower tynes **930** and **932** can be flexed toward each other as the removable unit **902** is pulled away from the body **912** such that the protuberances **934a** and **934b** exit the notches **940a** and **940b**, respectively.

The rongeur **900** provides the ideal means for having both cutting elements—the cutting/storage member **950** and the foot plate **916**—being replaceable when a second cutting element is present in the form of a raised and sharpened cutting edge on the foot plate **916** sufficient to provide a cutting edge but not to hold a substantial amount of bone such that it would prevent the bone from being advanced into the cutting/storage member **950**. When the foot plate **916** contains a cutting edge, it is preferable that the entire end unit **902** be disposable such that fresh, sharp cutting elements are provided with each use.

The rongeur **900** also provides the added advantages of having different sizes and configurations of the removable end unit **902** which can be used with the same body **912** increasing the versatility of the rongeur **900**, eliminating the need for having multiple rongeurs of different sizes and configurations and greatly reducing cost, especially if the rongeur **900** is power actuated.

For example, the end unit **902** may have a foot plate **916** that is angled relative to the shaft **916** in a specific orientation for a particular surgical procedure such that a number of specialized end units **902** may be provided for use with the body **912**. The end unit may have a shaft **914** and cutting/storage member **950** of different lengths, diameters and the overall configuration of the end unit **902** may be rounded for use in endoscopic procedures as described in reference to FIGS. **28** and **29**. In such cases, the entire end unit **902** may be entirely disposable or the end unit **902** may comprise any of the cutting/storage members described above having a disposable portion such as the straw **90** described above in reference to FIGS. **8** and **9**.

It is further appreciated that while the body **912** is shown with a manually operated handle, any of the embodiments of the power handles described above in reference to FIGS. **11–16** may be modified to drive the rongeur **900** without departing from the scope of the present invention.

Referring to FIG. **33**, an alternative embodiment of the rongeur of the present invention is shown and generally referred to by the numeral **1000**. Rongeur **1000** has a shaft **1014** and a cutting/storage member **1050** that are preferably rounded over their entire length, but may be more limitedly rounded in the area of the shaft and handle junction. The cutting/storage member **1050** preferably has a straw **1090** similar to the straw **90** described above in reference to FIGS. **8** and **9**, except that it is in communication with a vacuum pump **1092** via a hose **1094**. The vacuum pump **1092** functions to evacuate any cut pieces of bone or cartilage and cogenerated debris from the straw **1090** resulting from the cutting action of the rongeur **1000**. The hose **1094** forms an airtight seal with the straw **1090** to prevent vacuum loss and any contamination of the wound with the cut pieces of bone or cartilage or cogenerated debris. The use of a vacuum pump **1092** or similar means well known by those skilled in the art in association with rongeur **1000** is especially advantageous when the rongeur **1000** is being used in endoscopic surgical procedures where the presence of cut pieces of bone or cartilage and/or cogenerated debris interferes with the endoscopic procedure.

While the rongeur **1000** has been described with the cutting/storage member **1050** having a straw **1090** in communication with the vacuum pump **1092**, it is appreciated that any of the embodiments of the cutting/storage member

described above may also be modified to be in communication with vacuum pump **1092** or similar means well known by those skilled in the art to evacuate any cut pieces of bone or cartilage and/or cogenerated debris from the cutting/storage member without departing from the scope of the present invention. While the present invention has been described in association with the preferred embodiment and several alternative embodiments, it is recognized that other variations of the present invention may be made without departing from the scope of the present invention. Further, it is appreciated that any of the manually activated embodiments of the rongeurs described above may also be made to be electrically powered and similarly the electrically powered embodiment may also be made to be manually activated without departing from the scope of the present invention.

What is claimed is:

1. A rongeur for cutting bone or cartilage, comprising:
 - a body;
 - a first shaft and a second shaft extending from said body and capable of reciprocating motion relative to each other, said first shaft terminating in a foot plate, said second shaft comprising a combined cutting element and storage member having a leading end and a trailing end opposite said leading end, said leading end having a first opening and a cutting edge adapted to contact said foot plate, said cutting edge and said foot plate moveable from a maximal separated open position to a closed position, the maximal volume of bone or cartilage capable of being cut when said cutting edge and said foot plate are moved from said open position to said closed position determining a full cut of bone or cartilage;
 - a storage area in communication with said first opening in said leading end of said combined cutting element and storage member, said storage area configured to collect and store more than two full cut pieces of bone or cartilage within said storage area, said combined cutting element and storage member in cooperation with said rongeur preventing the ejection of at least three full cut pieces of bone or cartilage from said storage area during operation of said rongeur; and
 - an actuator associated with said first and second shafts for providing reciprocating motion between said first and second shafts.
2. The rongeur of claim 1, wherein said combined cutting element and storage member is removably coupled to at least a portion of said second shaft.
3. The rongeur of claim 1, wherein said trailing end of said combined cutting element and storage member includes a second opening at said trailing end in communication with said storage area, said second opening adapted to be closed by a portion of said rongeur when in use.
4. The rongeur of claim 3, wherein said second opening is in communication with a vacuum for evacuating any contents of said combined cutting element and storage member.
5. The rongeur of claim 1, wherein said foot plate comprises a cutting surface which is out of the plane of the surface of the foot plate facing the cutting edge of said combined cutting element and storage member.
6. The rongeur of claim 1, wherein said combined cutting element and storage member includes at least a portion thereof that is replaceable.
7. The rongeur of claim 1, wherein said combined cutting element and storage member is at least partially disposable.
8. The rongeur of claim 1, wherein said actuator for providing said reciprocal motion of said first and second shafts relative to one another includes a solenoid.

9. The rongeur of claim 1, wherein said first and second shafts are configured to form a seal against gas or fluid leakage from within the body of a patient through which said rongeur passes during endoscopic surgical procedures.

10. The rongeur of claim 1, wherein at least one of said first and second shafts is removeably attached to said actuator.

11. A rongeur set for cutting bone or cartilage, comprising:

a handle; and

a plurality of removable units, each of said removable units being configured to removably engage said handle, each of said removable units including:

a shaft having a leading distal end and a trailing proximal end opposite said leading end, said shaft terminating in a foot plate at said leading end, and a cutting member in moveable engagement with said shaft, said cutting member having a cutting edge adapted to contact said foot plate and cut pieces of bone or cartilage,

said handle providing reciprocal motion of said cutting member and said shaft relative to one another, said handle being adapted to lock at least one of said removable units to said handle by linear insertion of said removable unit in a proximal direction into at least a portion of said handle.

12. The rongeur of claim 11, wherein at least one of said removable units has a configuration different from another of said removable units.

13. The rongeur of claim 12, wherein at least one of said removable units is configured for use in endoscopic surgery.

14. The rongeur of claim 11, wherein at least one of said removable units has an angle between said footplate and said

shaft that is different from an angle between said footplate and said shaft of another one of said removable units.

15. The rongeur of claim 11, wherein at least one of said removable units is disposable after a surgical procedure.

16. The rongeur of claim 11, wherein each said removable units comprises at least one engagement member and said handle comprises at least one opening for receiving an engagement member.

17. The rongeur of claim 16, wherein said at least one engagement member is a tyne.

18. The rongeur of claim 16, wherein said at least one engagement member is flexible.

19. The rongeur of claim 16, wherein said at least one engagement member includes a protruberance and said at least one opening is configured to receive said protruberance.

20. The rongeur of claim 16, wherein said at least one opening includes a detent configured to cooperatively engage said at least one engagement member.

21. The rongeur of claim 16, wherein said handle comprises a spring lock configured to lock one of said removable units to said handle.

22. The rongeur of claim 11, wherein said handle includes at least one solenoid for providing reciprocating motion between said cutting member and said shaft of each removable unit.

23. The rongeur of claim 11, wherein said footplate of at least one of said removable units has a cutting edge.

24. The rongeur of claim 11, wherein said footplate of at least one of said removable units is removable from said shaft.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,575,977 B1
DATED : June 10, 2003
INVENTOR(S) : Gary K. Michelson, M.D.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page.

Item [63], **Related U.S. Application Data**, delete “which is a continuation-in-part of application No. 08/108,908 filed on Aug. 18, 1993, now U.S. Pat. No. 6,200,320, which is a continuation-in-part of application No. 07/905,127, filed on Jun. 24, 1992, now abandoned, which is a continuation of application No. 07/398,987, filed on Aug. 28, 1989, now abandoned, which is a continuation-in-part of application No. 07/341,849, filed on Apr. 24, 1989, now U.S. Pat. No. 5,009,661”.

Signed and Sealed this

Twenty-third Day of September, 2003

A handwritten signature in black ink, appearing to read "James E. Rogan", with a horizontal line underneath.

JAMES E. ROGAN
Director of the United States Patent and Trademark Office