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(54) SURGICAL INSTRUMENT HAVING DISTAL FACE WITH FIRST AND SECOND ELECTRODES

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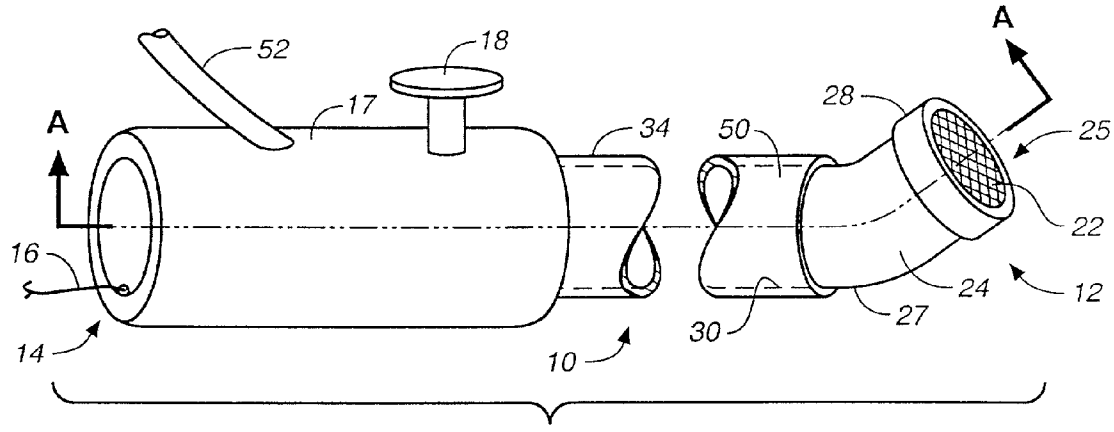
(57) **ABSTRACT**

An electrosurgical aspiration instrument that permits aspiration of an area being treated by the instrument. The instrument is coupled at a proximal end to a power source and includes an energy application surface area at a distal end. The power source supplied energy to the energy application surface area such that the distal end of the instrument may apply energy to the treatment area to modify the characteristics of biological material, such as biological tissue in the area. An aspiration lumen is formed through the instrument with an opening through the energy application surface area. The energy application surface area is configured to reduce blockage of the opening. Accordingly, aspiration may be performed simultaneously with electrosurgical treatment whereby unwanted matter such as by-products, biological debris and excess fluid is removed from the treatment area. The electrosurgical aspiration instrument also permits both functions to be performed at different times, with the advantage of not requiring instruments to be switched on during the treatment procedure or removed from the treatment site.



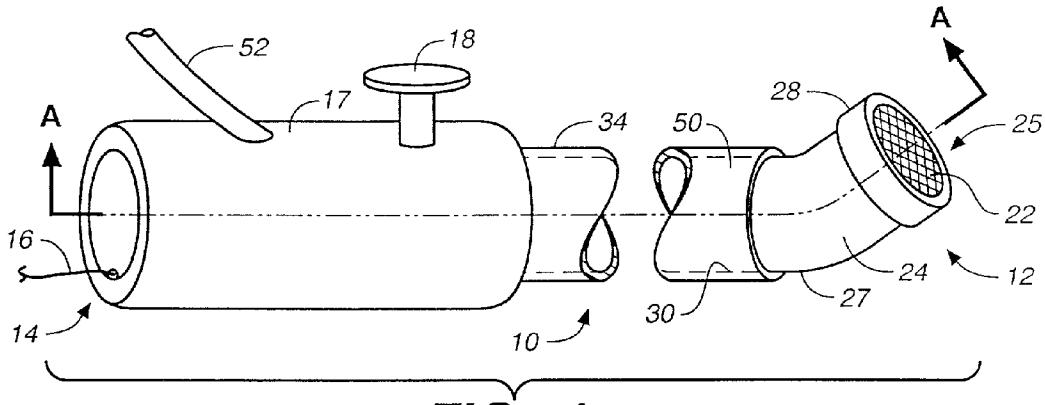


FIG._1

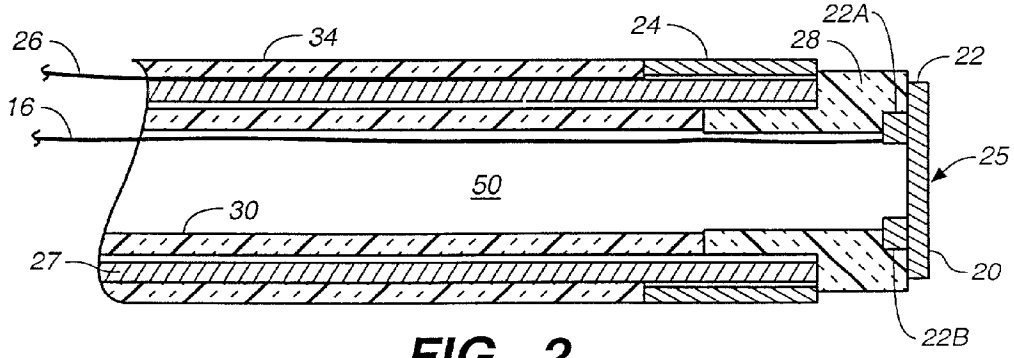


FIG._2

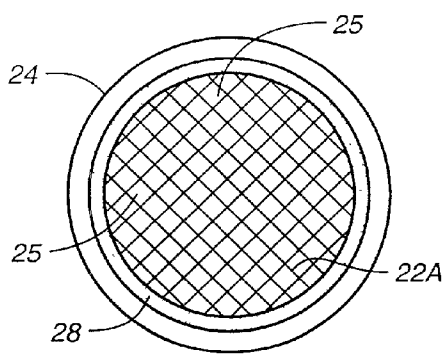


FIG._3

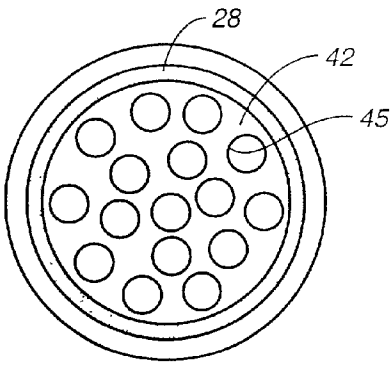


FIG._4

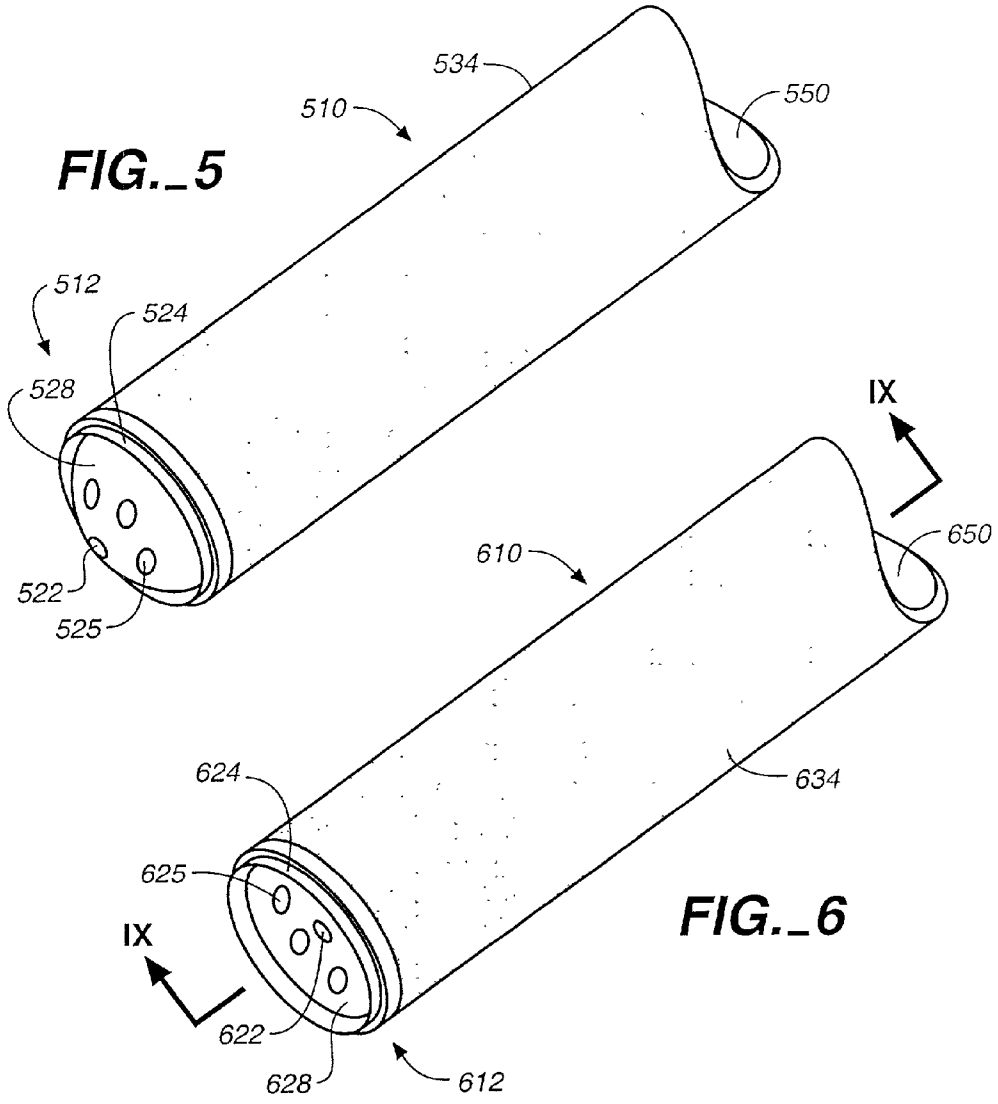


FIG._5

FIG._6

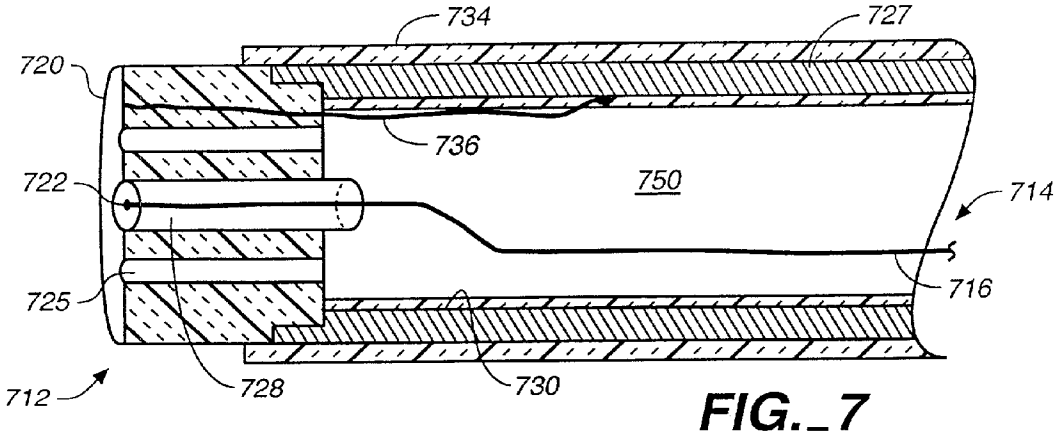


FIG._7

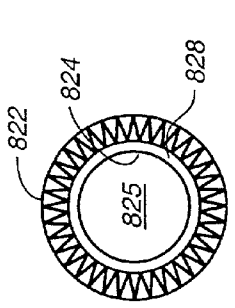


FIG._8B

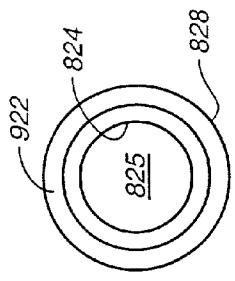


FIG._9B

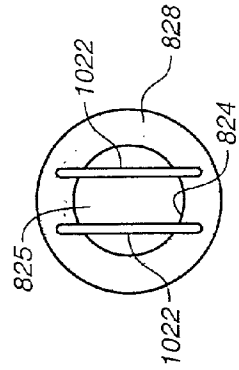


FIG._10B

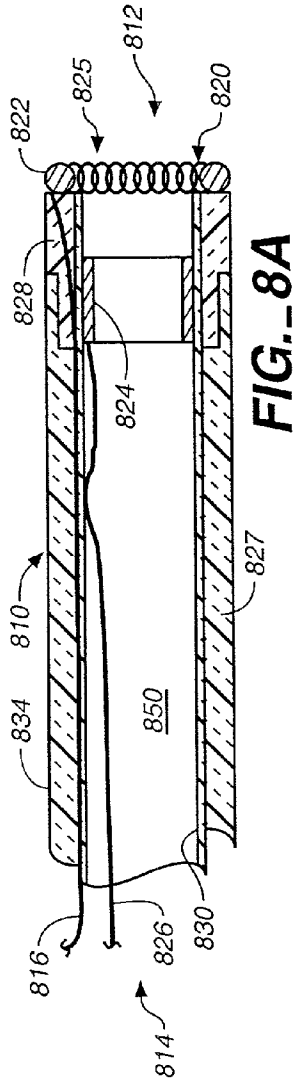


FIG._8A

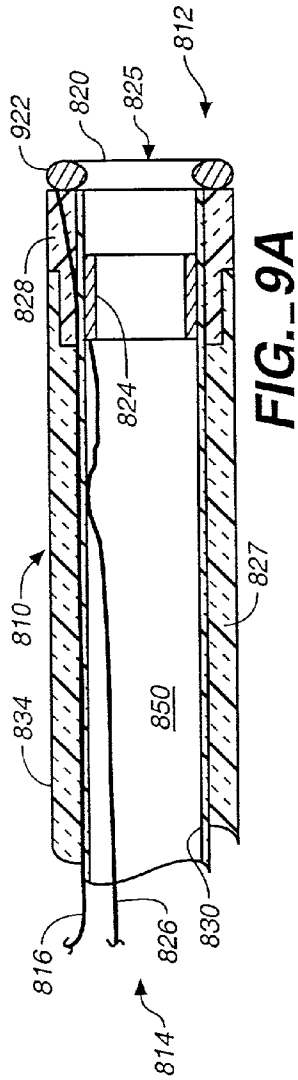


FIG._9A

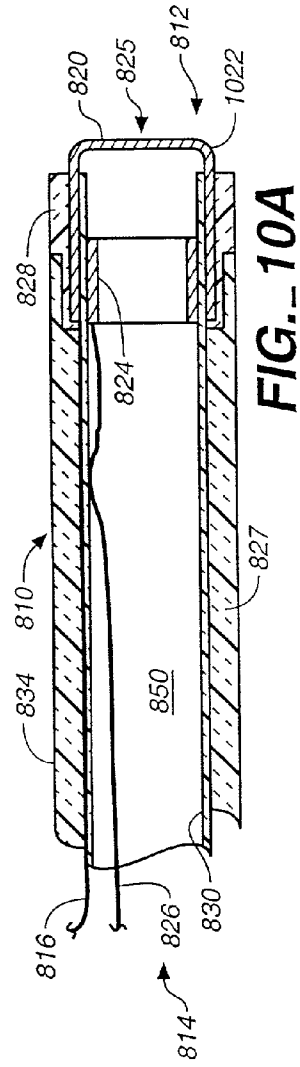


FIG._10A

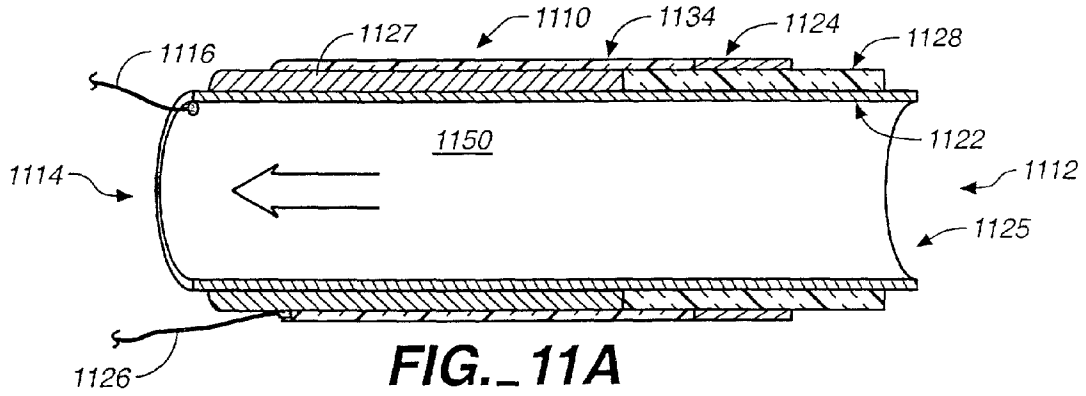


FIG._11A

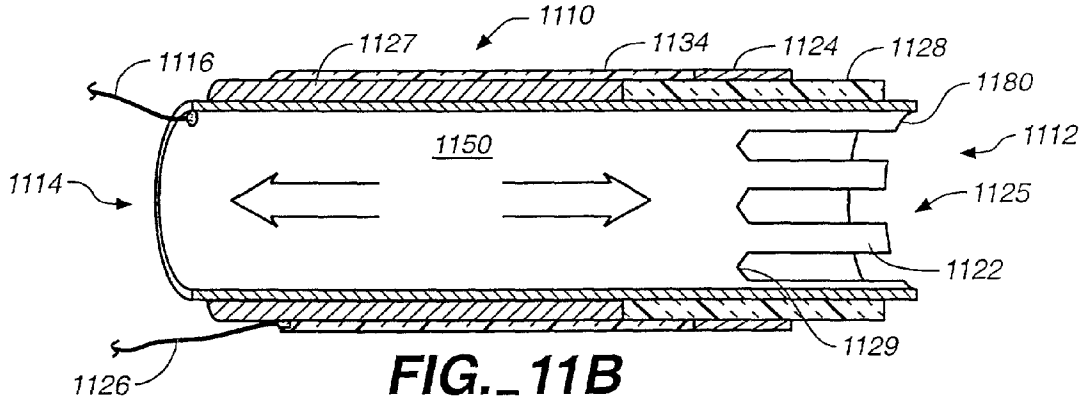


FIG._11B

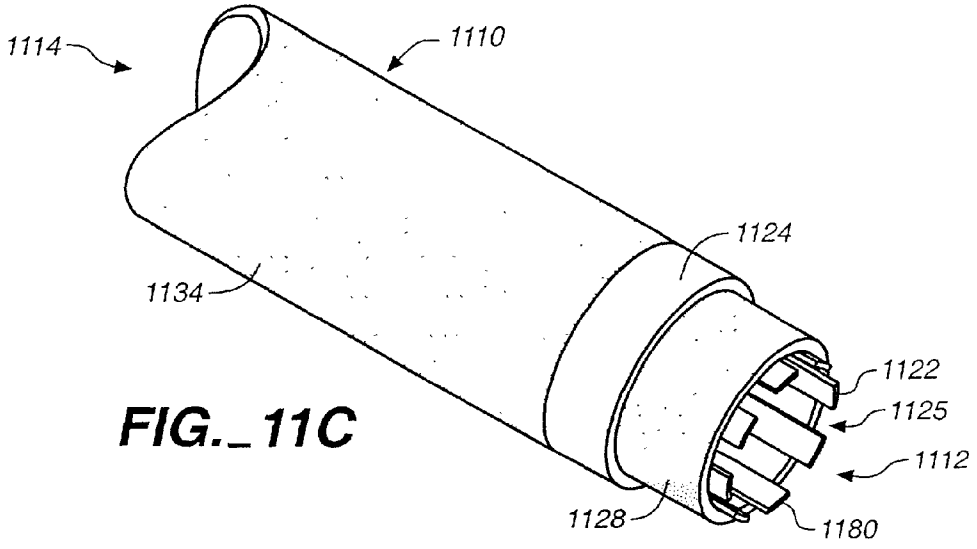


FIG._11C

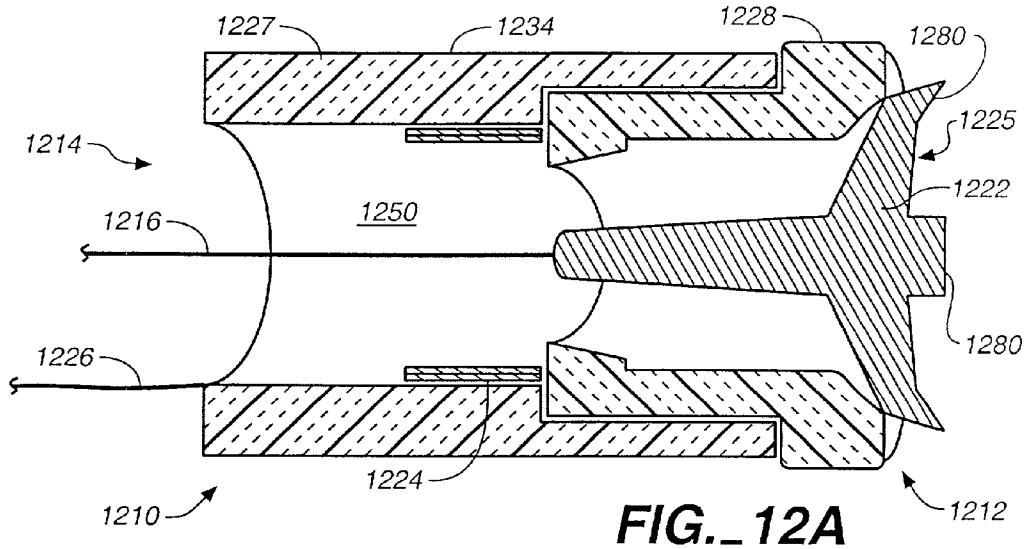


FIG._12A

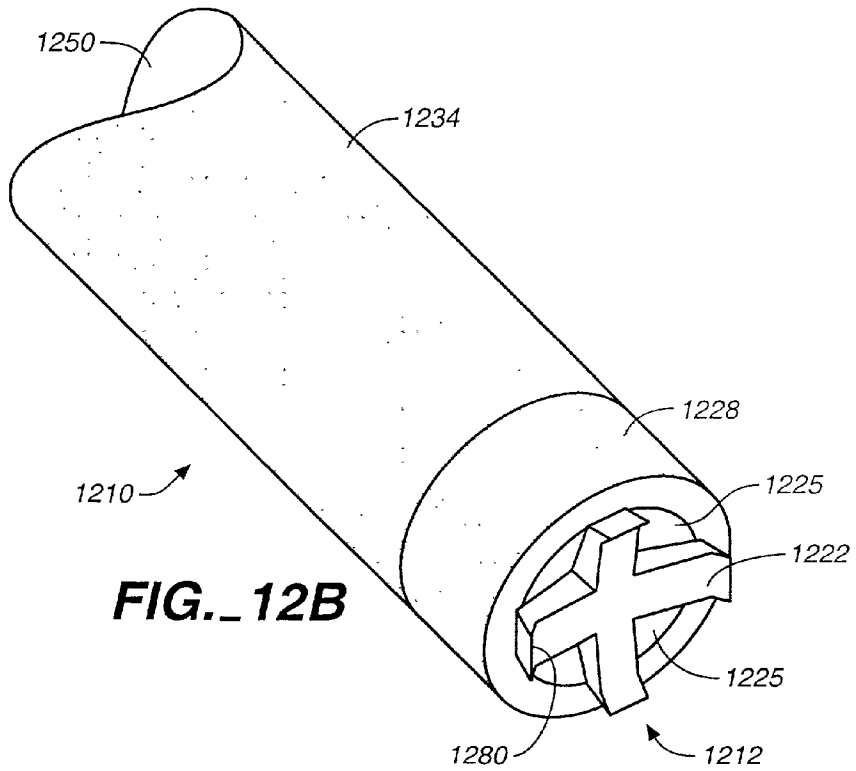


FIG._12B

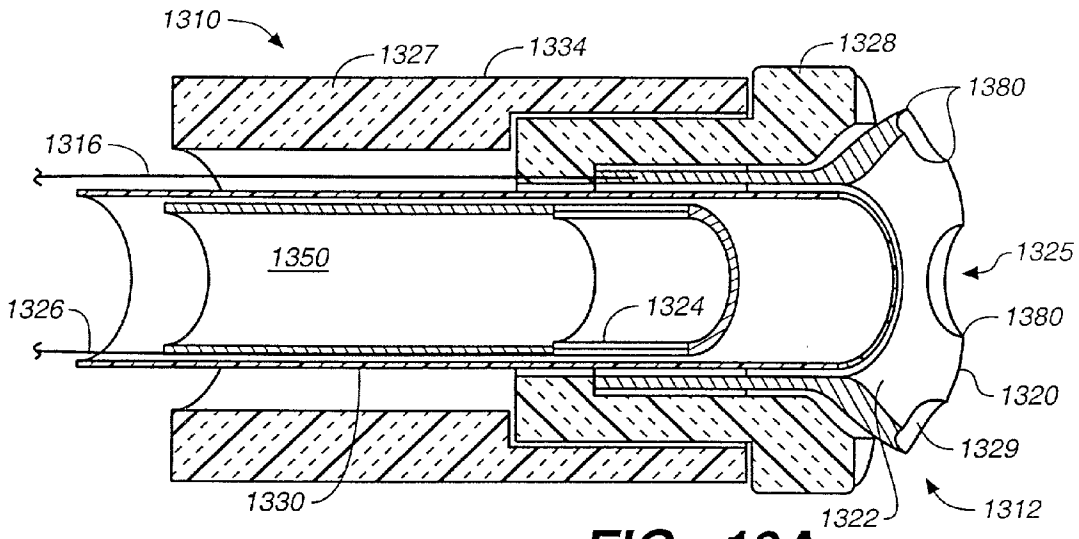


FIG._13A

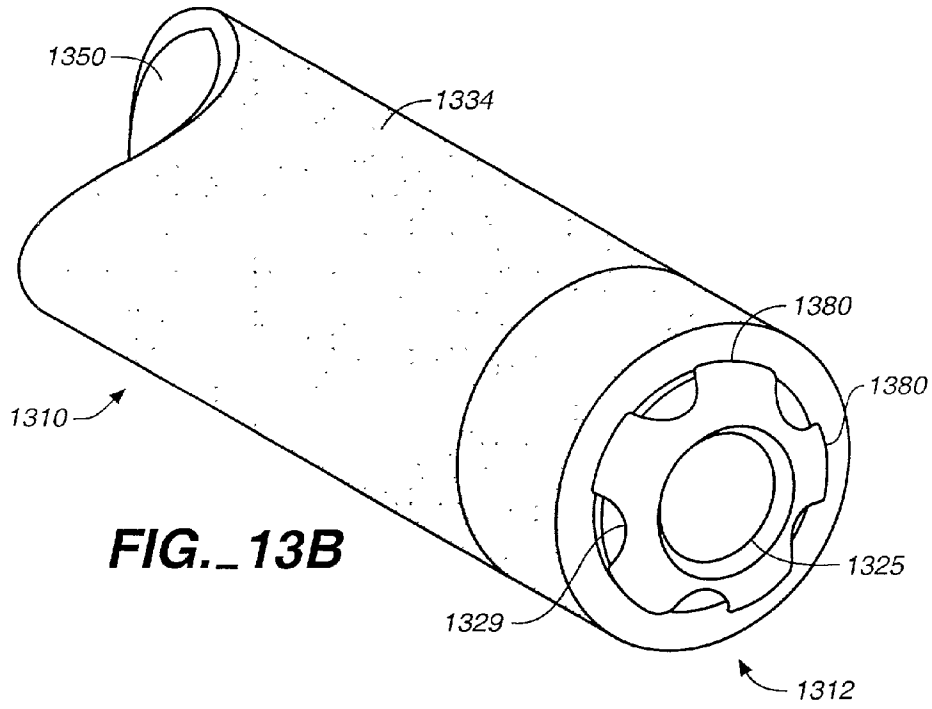


FIG._13B

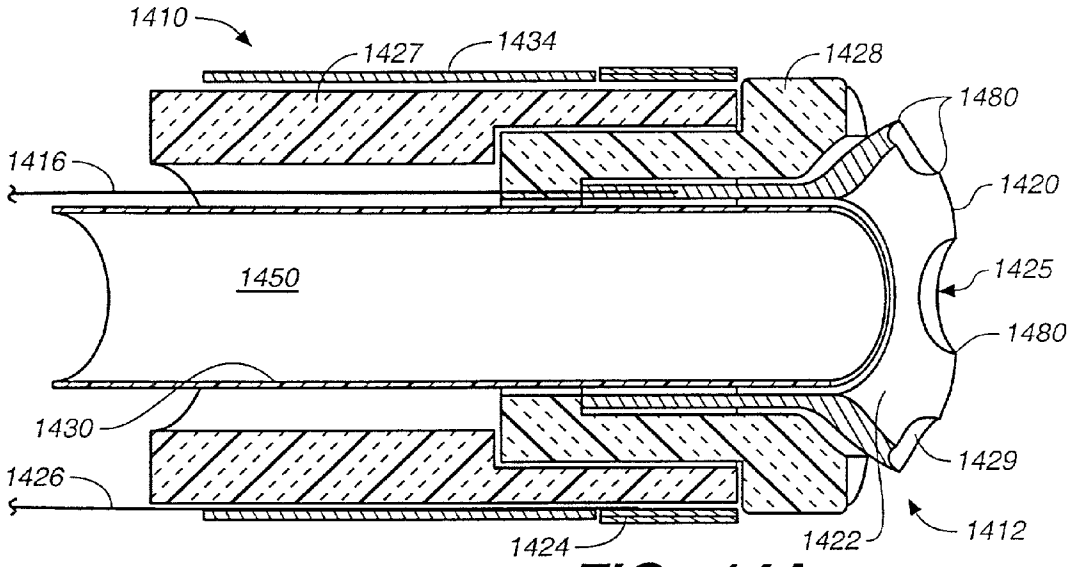
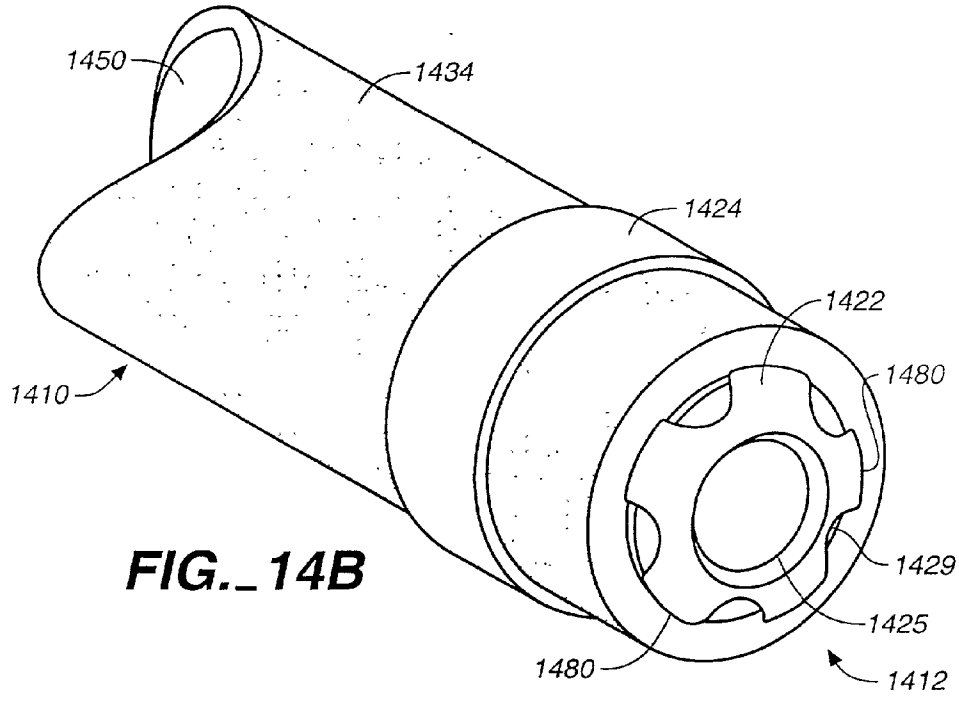


FIG._14A



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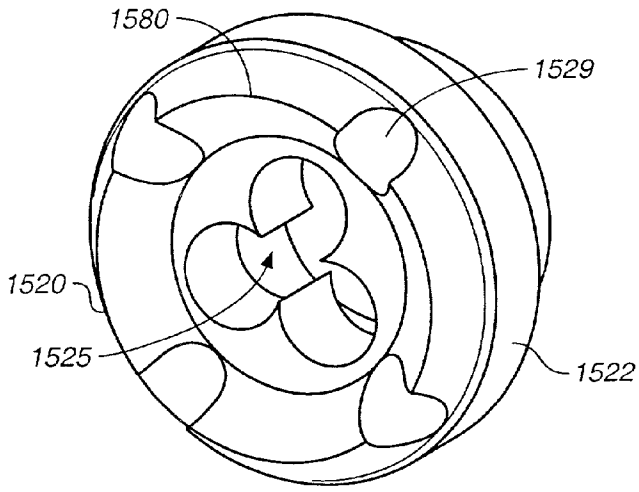

FIG._15A

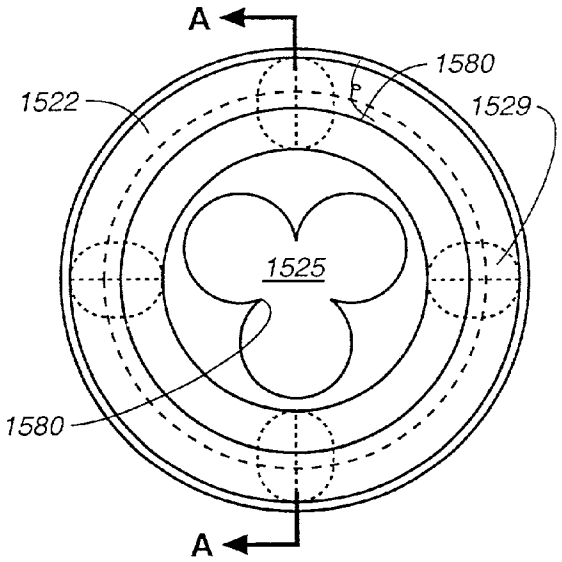

FIG._15B

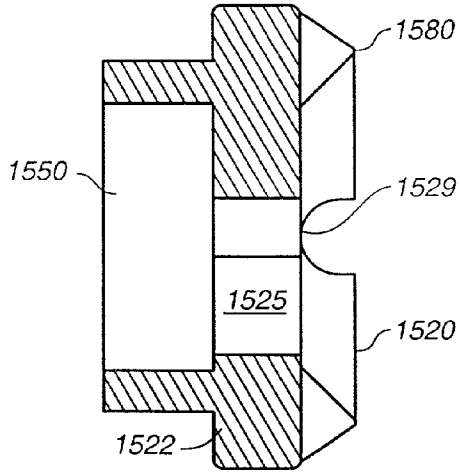

FIG._15C

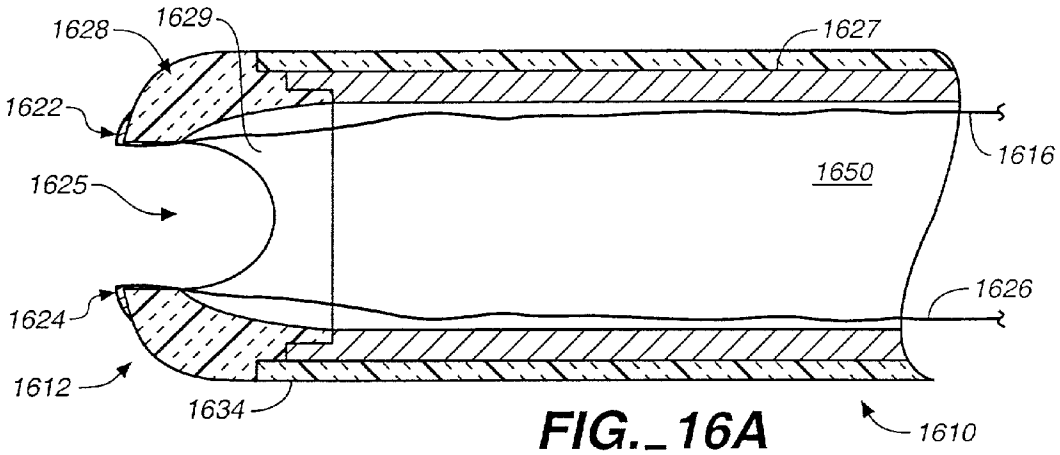

FIG._16A

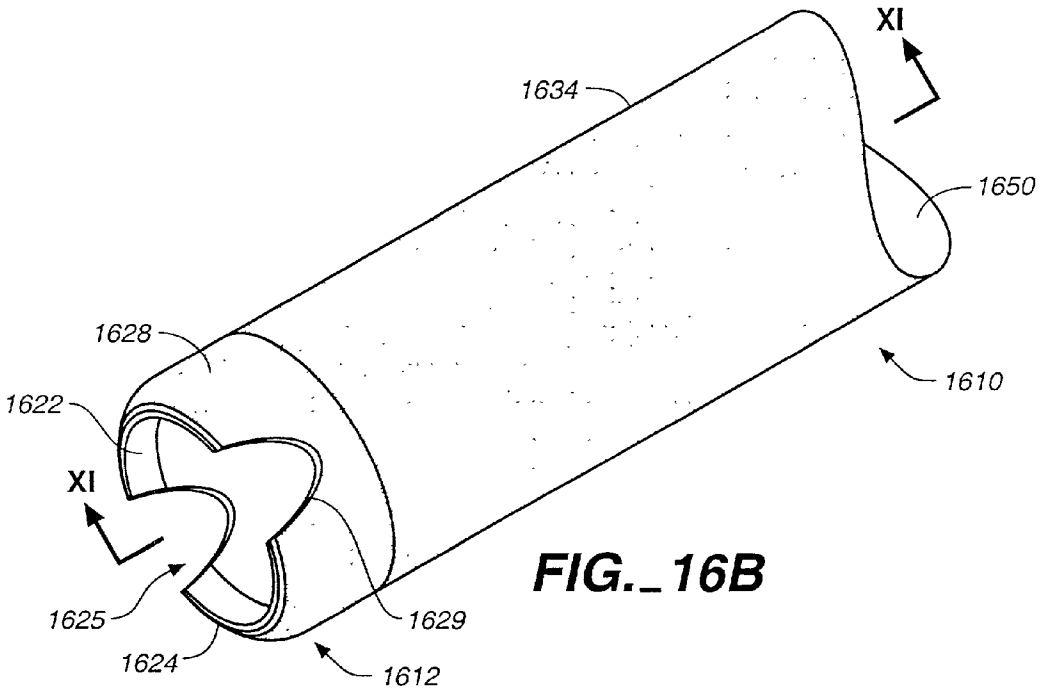

FIG._16B

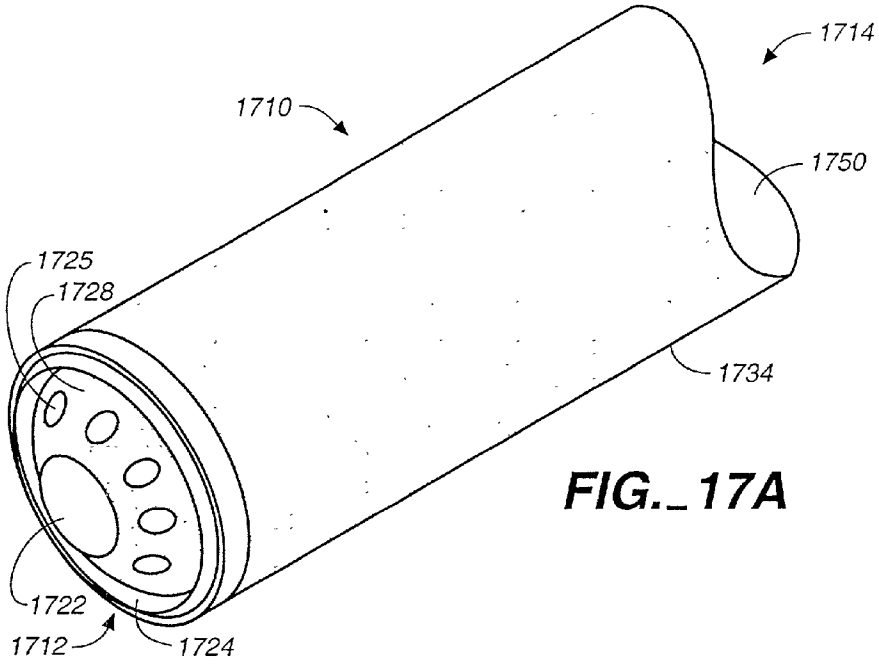

FIG._17A

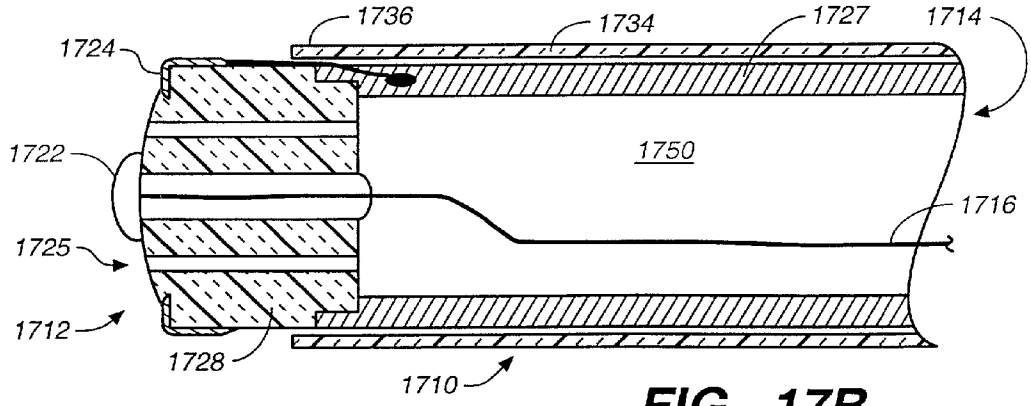

FIG._17B

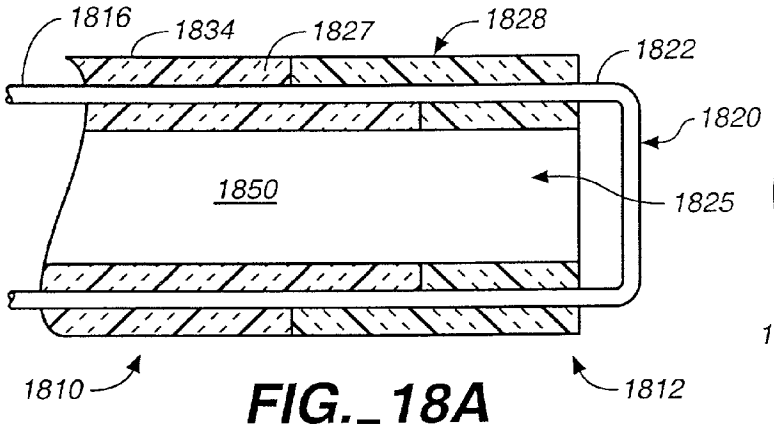

FIG._18A

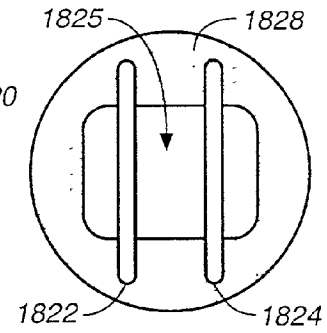

FIG._18B

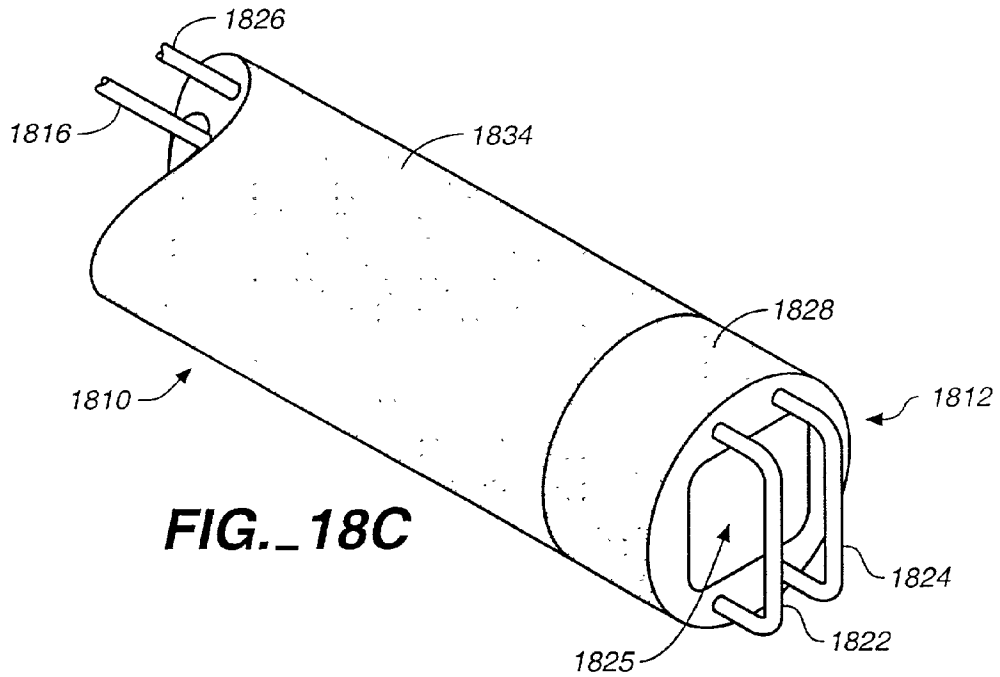

FIG._18C

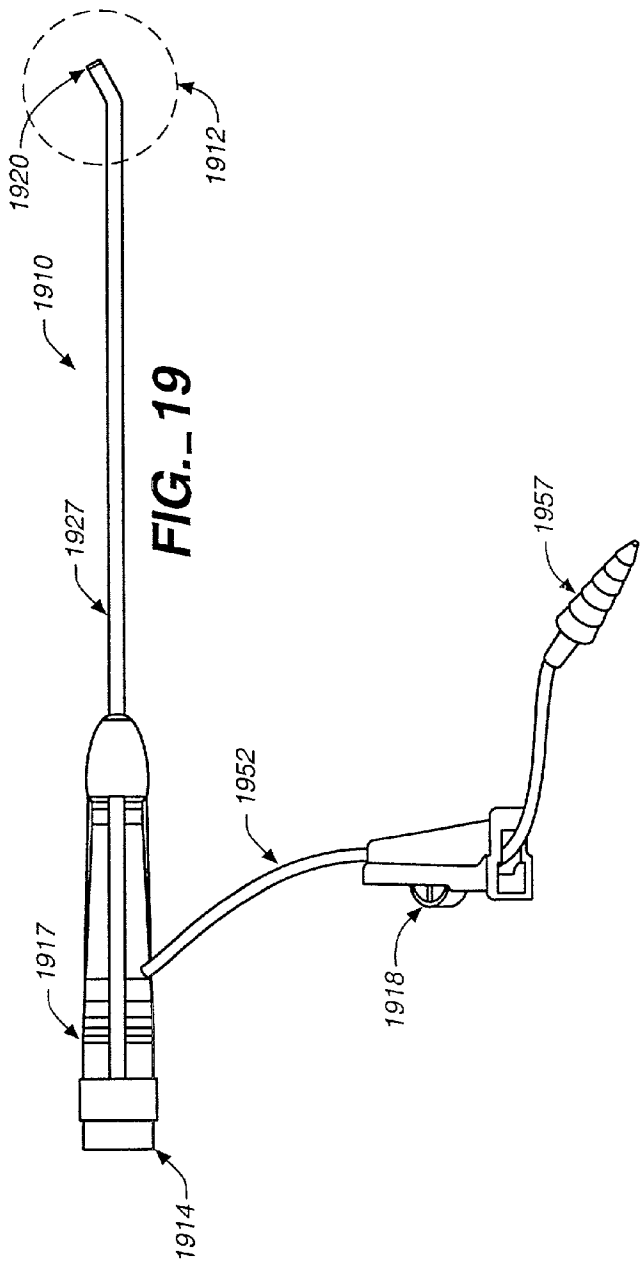

FIG._19

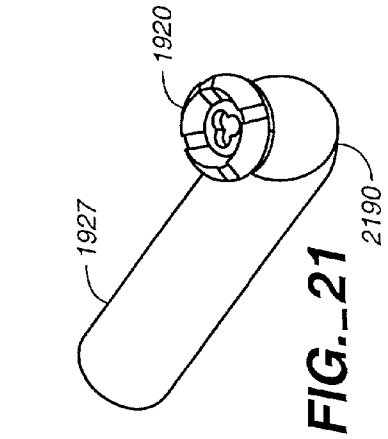

FIG._21

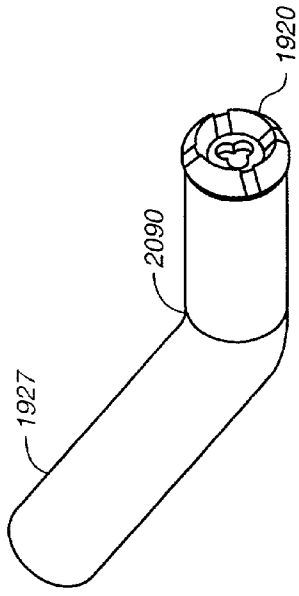

FIG._20

SURGICAL INSTRUMENT HAVING DISTAL FACE WITH FIRST AND SECOND ELECTRODES

BACKGROUND

[0001] The present invention relates to electrosurgical instruments and systems for treating a surgical site on a human or animal body such as biological tissue by the application of energy. More particularly, the invention relates to surgical devices and methods for applying high frequency energy to modify the characteristics of the tissue such as by ablation in combination with aspiration of any by-products from a surgical site.

[0002] Numerous surgical instruments for the treatment of biological tissue through the application of energy in a wide variety of medical procedures are known in the art. For example, U.S. Pat. No. 4,593,691 to Lindstrom et al., U.S. Pat. No. 4,033,351 to Hetzel, and U.S. Pat. No. 5,403,311 to Abele et al. are examples of electrosurgical probes for use during an electrosurgical procedure such as for cutting or ablating tissue. U.S. Pat. No. 5,458,596 to Lax et al. shows an example of an electrosurgical probe for the contraction of tissue by delivering electrical energy to the treatment tissue. Also, U.S. Pat. No. 3,828,780 to Morrison and U.S. Pat. No. 5,277,696 to Hagen show electrosurgical instruments which deliver electrical energy for coagulation during surgical procedures.

[0003] The use of these instruments typically involves the transmission of energy to a distal end of the electrosurgical probe or instrument. The distal end is inserted into the body to a surgical site of a patient to apply energy during the procedure. The frequency, power, and voltage generated by the electrical instrument and transmitted to the distal end are selected depending on the type of procedure for which the instrument is being used. For instance, such instruments are used for a variety of procedures such as heating, softening, shrinking, cutting and ablating tissue.

[0004] Because such instruments may be used for different procedures, the tissue (or other body part) being treated may respond differently depending on the treatment being performed. For instance, if the instrument is used to ablate the tissue, smoke and charring may be generated during the procedure or residual tissue debris may remain after treatment. Unwanted air bubbles or excess fluid may also be present in the treatment area that may interfere with effective treatment of the tissue and should be removed from the surgical site during the procedure. Thus, it is desirable to provide an electrosurgical device for aspirating the region being treated to remove smoke, tissue debris, excess fluid and other unwanted matter from the tissue site being treated.

[0005] During the usage of prior instruments, however, such as in numerous of the above-mentioned instruments, the removal of unwanted matter generally requires the separate provision of an aspiration device. The use of two separate instruments increases the treatment time because the suction instrument must be separately inserted into the surgical site, used, and removed from the site before and/or after the electrosurgical treatment instrument is inserted or used at the site. Additionally, a separate suction instrument may be inserted into the surgical site through another access point which creates another portal in the patient's body which possibly creates further complications such as infection and scarring.

[0006] U.S. Pat. No. 5,520,685 to Wojciechowicz, U.S. Pat. No. 4,682,596 to Bales and U.S. Pat. No. 4,347,842 to Beale disclose suction devices in various combinations and configurations with the electrosurgical probe. U.S. Pat. No. 5,195,959 to Smith also discloses an electrosurgical device with suction and irrigation to supply electrically conductive fluid which adds even more material to the surgical site and would need to be removed during the procedure. Wojciechowicz, in particular discloses a suction coagulator with a suction lumen for the suction of by-products of electrosurgery through the instrument through a tip. Further, Hagen discloses a suction device for aspirating fluid through the surgical probe.

[0007] However, the arrangement of the suction lumen in relationship to the electrosurgical portion is such that blockage or clogging of the suction lumen can occur which could complicate the surgical procedure and unwanted or unnecessary ablation could occur. Charred and ablated tissue and coagulated blood often clog the tips of electrosurgical devices.

[0008] Therefore, it would be desirable to provide an instrument that may be used not only to treat a patient but also to aspirate the treatment area during treatment to simultaneously remove unwanted material. The surgical device and method should be simple and operate in a standard surgical environment. The electrosurgical instrument should provide the surgeon the ability to ablate, cut or coagulate in the same device while providing a suction means to aspirate surgical by-products from the surgical site. The suction and aspiration should be anti-clogging such that the device does not cause unwanted nor undesirable effects due to blockage. Such instrument and method should be able to precisely treat biological tissue with energy while efficiently allowing the surgeon to perform the medical procedure quickly without the need to utilize multiple instruments for the treatment.

SUMMARY

[0009] It is, therefore, an object of the present invention to provide a surgical instrument and method for the application of energy to a treatment area of a patient and for the aspiration of unwanted matter, such as smoke, air bubbles and biological waste debris from the surgical site.

[0010] It is a related object of the present invention to provide a combination of electrosurgical and aspiration instrument that provides an energy application surface area that applies energy uniformly over the treatment area and also permits aspiration therethrough so as to limit clogging.

[0011] It is another object of the present invention to provide a combination electrosurgical and aspiration instrument having both an active electrode and a return electrode at a distal tip of the instrument such that energy distribution is substantially limited to the distal tip surface.

[0012] These and other objects and features are accomplished in accordance with the principles of the present invention by providing a probe having a cannula with at least one electrode for the transmission and application of energy to a treatment site along an energy application surface as well as a suction lumen through which unwanted matter and surgical by-products may be aspirated from the treatment area. Preferably, at least one electrode, an active electrode is

provided on a distal end of the probe. A return or indifferent electrode may located on the patients' body or on the probe. The instrument is coupled to an energy generator that preferable includes controls that may be used to regulate the power, frequency, and voltage applied to the instrument to vary the type of treatment for which the instrument is used. The regulation may include feedback controls.

[0013] In one embodiment of the invention, the active electrode is provided with a plurality of small passages therethrough in a fluid communication with the suction lumen of the instrument. An active electrode with such aspiration passages may be in the form of a mesh, a disc having perforations therethrough, or plural conductors supported by an insulator with apertures therethrough. Thus, aspiration of the treatment area occurs through at least a portion of the energy application surface. If desired, both the active and return electrodes may be positioned in substantially the same plane such that energy distribution is substantially restricted to a substantially planar surface area, such as the surface area of the distal tip.

[0014] In an alternative embodiment of the present invention, the surgical instrument has a shaft having distal and proximal ends. The shaft also defines at least one lumen. The lumen has at least one aspiration opening at the distal end. An active electrode is located at the distal end of the shaft which defines an energy application surface. The active electrode is electrically coupled to a power source. A return electrode is coupled to the power supply such that a current path from the active electrode to the return electrode passes over the aspiration opening to prevent clogging of the opening. The return electrode may be located on a portion of the body of a patient or on the shaft.

[0015] As negative pressure is applied to the lumen, matter that is in the surgical site is aspirated through the aspiration opening. The opening is configured to prevent clogging of the aspirated matter at the distal end. The aspiration opening may be defined by the active electrode which is configured to prevent clogging of the aspiration opening and allow continued desiccation of the unwanted aspirated matter such that the matter will move easily through the aspiration lumen.

[0016] These and other features and advantages of the present invention will be readily apparent from the following drawings and detailed description of the invention, the scope of the invention being set out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The detailed description will be better understood in conjunction with the accompanying drawing, wherein like reference characters represent like elements, as follows:

[0018] **FIG. 1** is a perspective view of an electrosurgical aspiration instrument formed in accordance with the principles of the present invention;

[0019] **FIG. 2** is a cross-sectional view along axis A-A of **FIG. 1**;

[0020] **FIG. 3** is an end view of a distal tip of the instrument of **FIG. 1**;

[0021] **FIG. 4** is an end view of a distal tip of the instrument of **FIG. 1** showing an alternative tip embodiment;

[0022] **FIG. 5** is a perspective view of an electrosurgical aspiration instrument according to the present invention with a distal tip active electrode having a convex configuration;

[0023] **FIG. 6** is a perspective view of an electrosurgical aspiration instrument according to the present invention with a distal tip active electrode having a concave configuration;

[0024] **FIG. 7** is a cross-sectional view of a basic distal tip portion of the instrument of **FIGS. 5 and 6**.

[0025] **FIGS. 8A and 8B** are cross-sectional and end views, respectively, of an electrosurgical aspiration instrument showing one embodiment of an active electrode in a coil configuration with an internal return electrode;

[0026] **FIGS. 9A and 9B** are cross-sectional and end views, respectively, of an electrosurgical aspiration instrument according to the present invention showing an active electrode in a ring configuration with an internal return electrode;

[0027] **FIGS. 10A and 10B** are cross-sectional and end views, respectively, of an electrosurgical aspiration instrument according to the present invention showing one embodiment of an active electrode in a prong configuration with an internal return electrode;

[0028] FIGS. **11**A-C are cross-sectional and perspective views, respectively, of an electrosurgical aspiration instrument according to present invention having a mechanical grating configuration of the active electrode with an external return electrode; **FIG. 11A** is a ring grating configuration; **FIG. 11B** is a rasp grating configuration;

[0029] **FIGS. 12A and 12B** are cross-sectional and perspective views, respectively, of an electrosurgical aspiration instrument with an alternative embodiment showing an active electrode having a cross configuration for mechanical grating and delivery of energy;

[0030] **FIGS. 13A and 13B** are cross-sectional and perspective views, respectively, of an alternate aspiration instrument of **FIGS. 12A and 12B** with an active electrode having an ashtray configuration for mechanical grating and energy delivery with an internal return electrode;

[0031] **FIGS. 14A and 14B** are cross-sectional and perspective views, respectively, of the instrument of **FIGS. 13A and 13B** showing an external return electrode;

[0032] FIGS. **15**A-C are detailed perspective, end, and cross-sectional views of the distal tip of an electrosurgical aspiration instrument according one embodiment of the present invention; **FIG. 15A** is a detailed perspective view of an active electrode with an aspiration opening; **FIG. 15B** is an end view of the active electrode; and **FIG. 15C** is a cross-sectional view along line A-A of the active electrode of **FIG. 15B**;

[0033] **FIGS. 16A and 16B** are cross-sectional and perspective views of an alternative embodiment of the instrument present invention wherein the distal tip is a true bipolar configuration having a single aspiration opening;

[0034] **FIGS. 17A and 17B** are perspective and cross-sectional views of an alternate embodiment of the instrument according to the present invention showing a true bipolar configuration of the distal tip having multiple aspiration openings;

[0035] FIGS. **18**A-C are cross-sectional, end and perspective views of an alternative embodiment of the distal tip having a single aspiration opening with both active and return electrodes formed by loop prongs defining the energy application surface;

[0036] **FIG. 19** is a perspective view of the complete electrosurgical instrument of the present invention showing a probe having a handle and a shaft with a distal tip for treatment with a suction line and control; and

[0037] **FIGS. 20 and 21** are alternative embodiments of the distal end shaft of **FIG. 19** according to the present invention having a pre-bent distal end in a 30 degree configuration and a 90 degree configuration, respectively.

DETAILED DESCRIPTION OF THE INVENTION

[0038] An embodiment of an electrosurgical aspiration instrument **10** capable of aspirating a patient treatment area within a standard surgical environment in accordance with the principles of the present invention is illustrated in **FIGS. 1 and 2**. Electrosurgical aspiration instrument **10** is in the form of a probe having, generally, a shaft **27** disposed along longitudinal axis A-A, a distal end **12** at which treatments are performed and a proximal end **14** at which instrument **10** is coupled to a power source (not shown) via power line **16**. Power line **16** supplies energy to distal end **12** for treatment. The power source preferably permits modification and adjustment of the power, frequency, and voltage of the energy transmitted to distal end **12**. A handle **17** may be provided to facilitate grasping of instrument **10** adjacent proximal end **14**. At least one actuator **18**, such as an aspiration control valve or switch or a power button may be provided. In a preferred embodiment, a foot pedal (not shown) is provided to control power supplied to distal end **12** and actuator **18** controls aspiration through the instrument. Additional actuators or controllers, such as for adjusting the power, frequency, or voltage, may be provided either on instrument **10** itself or on the power source if desired.

[0039] Electrosurgical aspiration instrument **10** has an energy application surface or plane **20** formed by at least one electrode that applies energy to the patient area to be treated. In one embodiment, instrument **10** has at least two electrodes, active electrode **22** and return electrode **24** that cooperate to apply energy across surface **20**. Electrodes **22** and **24** are formed from electrically conductive materials, for example a medical grade stainless steel, capable of withstanding the high temperatures resulting from use of instrument **10**. It will be appreciated that the material that is selected for electrodes **22** and **24** has defined conductivity characteristics that affects the power necessary to achieve the desired treatment operation.

[0040] As shown in **FIGS. 1 and 2**, active electrode **22** is positioned at the open distal end of shaft **27** of electrosurgical aspiration instrument **10**. Although shaft **27** may be a separate element, preferably, return electrode **24** serves a dual purpose as both the return electrode that completes the energy circuit with active electrode **22** as well as the shaft of instrument **10**. It will be appreciated that the arrangement of electrodes **22** and **24** may be reversed, such that the active electrode is in the form of a shaft with an open distal end on which the return electrode is positioned. Alternatively, the return electrode may be located on a point external to the treatment site such as placing a grounding pad or plate on the body (not shown).

[0041] Power is transmitted to active electrode **22** from power line **16** via a conductive element **26**, such as a wire, as shown in **FIG. 2**. Return electrode **24**, as described above, is preferably in the form of an electrically conductive shaft, preferably formed from **304** stainless steel or any other biocompatible conductive material, that extends from distal end **12** of instrument **10** to proximal end **14**. The end of return electrode **24** adjacent proximal end **14** of instrument **10** is coupled to the power source to communicate the power source at proximal end **14** with distal treatment end **12** and thereby to complete the energy supply circuit of electrosurgical aspiration instrument **10**. If desired, the shaft forming a return electrode **24** may be formed from a malleable material so that it is shapeable by the user. However, the distal-most end of instrument **10** should not be flexible. Additionally, any bend imparted to instrument **10** should not be so extreme as to close off the lumen formed therethrough and described in further detail below.

[0042] Electrodes **22** and **24** are electrically isolated from each other such that electrical arcing between active electrode **22** and return electrode **24** generates treatment energy along energy application surface **20** that may be applied to the patient. Electrical isolation or insulation of electrodes **22** and **24** at energy application surface **20** may be accomplished by the provision of insulator **28** therebetween. Insulator **28** is formed from many desired insulative material, such as ceramic, teflon or pyrolytic carbon, that may withstand the high temperatures that may result upon application of energy at distal end **12** during use of the instrument **10**. Preferably, active electrode **22**, return electrode **24**, and insulator **28** permit fluid communication through instrument **10** from the treatment area at which energy application surface **20** is applied to proximal end **14**, as described in further detail below.

[0043] In addition, electrodes **22** and **24** must also be electrically isolated axially along longitudinal axis **11** between proximal end **14** (at which instrument **10** applies treatment energy) so that power supply to energy application surface **20** is not shorted. Although insulation on wire **26** is typically sufficient to electrically insulate active electrode **22** from return electrode **24**, optional insulation **30** on interior surface **32** of return electrode **24** may be provided. Insulation **30** is selected from biocompatible and electrically insulative material which could include nylon, polyimide or other shrink tubing and also functions to limit the heat transfer to the shaft. If active electrode **22** (rather than return electrode **24**) is coupled to the power source via a conductive shaft as mentioned above and described with respect to the embodiments of FIGS. **8-11**, insulation **30** would be more desirable. An insulative cover **34**, such as formed from a teflon coating or a heat shrink cover, is provided over exterior surface **36** of return electrode **24** to restrict the extent of arcing and hence energy supplied to distal treatment end **12** of instrument **10**.

[0044] Instrument **10** may be substantially straight, or may have a slight bend at distal end **12** such that energy application surface **20** is slightly offset form longitudinal axis **11**. As shown in **FIGS. 1 and 2**, the energy application surface **20** of electrosurgical aspiration instrument **10** extends along

distal end **12** (approximately transverse to longitudinal axis A-A in a straight instrument). However, it will be appreciated that electrodes **22** and **24** may be provided at different positions at distal end **12** to alter the location of energy application surface **20**.

[**0045**] Electrosurgical aspiration instrument **10** may be used for a variety of electrosurgical treatments. On particular use of instrument **10** is for ablation of human or animal tissue. Because ablation generally occurs at very high temperatures, e.g. 300-1000 degrees Celsius, smoke and/or vapor may be generated during ablation. It may be desirable to remove smoke; unwanted or excess gases, such as air bubbles; fluids, such as irrigation fluid required to irrigate or enhance conduction after treatment; from the treatment area during treatment. Moreover, debris or other materials or biological elements may remain after the ablation procedure that should be removed from the treatment area. Thus, in accordance with the principles of the present invention, instrument **10** is also designed to aspirate such unwanted matter from the treatment area during the electrosurgical procedure performed thereby. It will be appreciated that aspiration may be performed either simultaneously with, before, or after electrosurgical treatment of an area. Further, it should be appreciated that a power source may be used which sequentially, or in a predetermined sequence, supplies power to the active electrode and then provides power for aspiration. Accordingly, an aspiration lumen **50** is provided within electrosurgical aspiration instrument **10** along longitudinal axis A-A. Aspiration lumen **50** may be formed by interior wall or surface **32** of return electrode **24** and is in fluid communication with a aspiration line **52** which couples proximal end **14** of instrument **10** with a vacuum source of other aspiration device (not shown). Aspiration line **52** is preferably standard tubing for connection to a suction source and device.

[**0046**] In order to facilitate aspiration during electrosurgical treatment, such as during ablation or coagulation, instrument **10** is provided with an aspiration means which permits aspiration through energy application surface **20**. This is accomplished by providing at least one through-hole or aperture **25** through active electrode **22** which defines surface **20**. Alternatively, a plurality of through-holes or apertures through active electrode **22** may be used to aid in aspiration of the electrosurgical probe. In the embodiment of **FIGS. 1 and 2**, active electrode **22** is in the form of a wire mesh or screen **22**A supported by an electrically conductive ring **22**B. Mesh **22**A and ring **22**B comprising active electrode **22** are formed from a conductive materials, such as stainless steel, tungsten, or titanium or their alloys, that can withstand the high temperatures resulting from use of instrument **10**. The entire mesh and ring of active electrodes **22** serves as the energy application surface and is powered by the power supply so that the electrosurgical application, such as ablation, occurs over the electrode. Thus, the active aspiration is approximately co-extensive with energy application surface **20**. The preferred range of mesh sizes is from approximately 30 mesh to approximately 55 mesh.

[**0047**] The interstices between the mesh permit fluid communication therethrough such that unwanted matter (e.g., ablated tissue, smoke, air bubbles, and other elements or biological debris) may pass through the mesh and into aspiration lumen **50** for transport away form the treatment area. Moreover, because power is supplied substantially uniformly over the entire mesh of active electrode **22**, unwanted matter that is too large to fit through the interstices of the mesh are caught on the mesh and accordingly ablated thereby when power is applied to the electroconductive mesh. As the mesh heats up, the matter is ablated until it becomes small enough to fit through the mesh. It will be appreciated that the energy application surface has a uniform electrical potential being one piece across the surface of the mesh. Additionally, a blockage occurring at one portion of the mesh causes an increase in the suction force at unblocked portions of the mesh forming a non-uniform suction path. As the suction force increases in the unblocked areas, a differential axial suction force is created in which the blockage is turned and twisted to continue ablation and pass through apertures **25** to be aspirated through aspiration lumen **50**. Thus, active electrode **22** not only provides treatment energy but also permits aspiration therethrough, as well as destruction of larger pieces of unwanted matter during aspiration which might otherwise clog the aspiration lumen **50**.

[**0048**] Moreover, in the present embodiment, return electrode **24** is located on shaft **27** proximal to active electrode **22**. This defines a unipolar configuration where the return electrode **24** has a larger surface area than active electrode **22** functions as an indifferent return to the power source and the energy is diffuse around electrode **24**. This provides the active electrode **22** with a higher current density such that treatment energy is crowded and the treatment effect is generally in the area of tissue in proximity to active electrode **22**. In an alternative embodiment, however, return electrode **24** may be located on a surface on the patient's body in the form of a grounding plate or pad. In this configuration, the return electrode functions to return the treatment energy to the power source to define a monopolar configuration.

[**0049**] Referring to **FIG. 3**, the electrosurgical probe of **FIGS. 1 and 2** is illustrated in an end view. Mesh **22**A of active electrode **22** forms the energy application surface. The spacing between the mesh form multiple apertures **25** to allows for suction of unwanted matter through the distal end and aspiration opening. Although a substantially flat piece of mesh may be used, the mesh may be formed into any desired shape to vary the contour of the contact surface provided by the mesh. For instance, the mesh forming active electrode **22** may be domed to conform substantially with concave body parts to be treated by electrosurgical aspiration instrument **10**. Pointed, convex, rippled, or other contours may be provided instead, depending on user preferences or other contours of the area to be treated. Insulator **28** electrically isolates active electrode **22** from return electrode **24**.

[**0050**] In **FIG. 4**, instead of providing active electrode **22** in the form of a mesh, active electrode **22** may take on an alternative form with apertures provided to permit aspiration therethrough. For example, active electrode **22** may be in the form of a disc or conductive plate **42** with perforations **45** formed therethrough. In an exemplary embodiment, such a plate may be secured within the distal end of annular insulator **28** in place of mesh electrode **22** as shown in **FIG. 2**. In a preferred embodiment, perforations **45** have a diameter of approximately 0.010-0.020 inches. In general, the perforations should be small enough to reduce particle size passing therethrough such that downstream clogging is minimized while large enough to provide effective aspiration without blockage of the distal tip **12**. Likewise, any

other type of conductive element formed as a honeycomb or other such shape that permits aspiration therethrough may be used.

[0051] Alternative configurations of electrodes which define an energy application surface and permit aspiration therethrough are illustrated in FIGS. **5-7**, as described below. It will be appreciated that the form of the active electrode may be modified as desired so long as external access to the internal lumen through the shaft of the electrosurgical aspiration instrument of the present invention is permitted. It will further be appreciated that the form and relative arrangement of the active electrode with respect to the return electrode may be modified as desired. However, it is desirable that the resulting energy application surface extends at least over a portion of the lumen opening to permit cooperation between the energy application surface and the process of aspiration. This provides for reduction in blockage.

[0052] Electrosurgical instrument **510** of **FIG. 5** has a substantially centrally located electrode **522** and a ring-shaped electrode **524** both of which are positioned at distal end **512** of instrument **510**. One of electrodes **522**, **524** is an active electrode and the other of electrodes **522**, **524** is a return electrode. Both electrodes are supported and electrically isolated by insulator **528**. A suitable insulative coating or covering **534** is provided over the exterior surface of instrument **510**. Apertures **525** permit aspiration as a suction force is applied to aspiration lumen **550** to draw unwanted matter through apertures and through the instrument **510**.

[0053] As shown in **FIG. 5**, insulator **528** has a convex working surface such that central electrode **522** is slightly distal of ring-shaped electrode **524** to form a unipolar configuration. However, it will be appreciated that a substantially flat working surface my be used instead such that the energy application ends of both electrodes are coplanar.

[0054] Alternatively, a concave working surface may be used, as in electrosurgical instrument **610** of **FIG. 6**, such that ring-shaped electrode **624** is slightly distal of central electrode **622**. The instrument **610** as shown in **FIG. 6** includes apertures **625** within insulator **628** for aspiration from the distal tip **612** through aspiration lumen **650**. Outer insulation **634** covers the instrument shaft.

[0055] The arrangement and electrical connections of electrodes **522** and **524** of electrosurgical instrument **510** may be appreciated with reference to **FIG. 7**. It will be understood that a similar arrangement may be used for electrosurgical instruments **510** and **610** as well. In the exemplary embodiment, **FIG. 7** illustrates a cross-section through shaft **727** showing electrical power conductor **716**, in the form of a wire extending proximally from a power source (not shown) located at proximal end **714** to distal **712** of instrument **710**. Power conductor **716** passes through lumen **750** and provides power to central electrode **722**. Electrical power conductor **736** is in the form of shaft **727** being electrically conductive and conductor **736** electrically coupled to return electrode **724** via extension **736**. Electrical conductors **716**, **726**, and **736** are electrically isolated from each other in any desired manner, such as in with insulative material such as interior insulation **730** in a manner described above. An insulative coating or covering **734** is provided on the exterior surface of instrument **710**, preferably to protect the patient from any energy discharge conducted through electrical conductor **736**.

[0056] Apertures **525**, **625**, and **725** are provided through insulator **528**, **628** or **728**, respectively, such that instruments **510**, **610**, and **710** also perform an aspiration function as previously described. In particular, the apertures provide for aspiration through the energy application surface which is defined by the electrode planes. It will also be appreciated that certain advantages in localized energy application may be realized due to the placement of both electrodes on the distal tip of the device.

[0057] It should be appreciated that active electrode in FIGS. **5-7** can be sized appropriately, relative to return electrode or vice versa, such that application of power to the active electrode and use of the electrosurgical instrument approximates the effect delivered by a bipolar electrosurgical instrument. In a typical bipolar instrument, both electrodes are of the same size and approximately located with in the same proximity such that both electrodes equally affect the tissue area to which the instrument is applied. By sizing the active electrode and the return electrode to be of approximately equivalent sizes, a bipolar effect may be achieved with the present invention. It should further be appreciated that it is possible to size the electrodes in any of the embodiments of the present invention so as to achieve a bipolar effect. The return electrode of the present invention may also be located on the patient's body as discussed above.

[0058] **FIGS. 8A and 8B**, **FIGS. 9A and 9B** and **FIGS. 10A and 10B**, illustrate similar embodiments of the electrosurgical aspiration instrument of the present invention.

[0059] For the sake of simplicity, descriptions of elements or features of the embodiments of FIGS. **8-10** that are substantially the same (and thus referenced by the same reference numbers) are not repeated in detail, reference being made to the description provided in connection with similar elements described with reference to FIGS. **8-10**.

[0060] **FIGS. 8A and 8B** illustrate one alternative embodiment of electrosurgical instrument **810** having an active electrode **822** in the form of a ringed coil on distal tip **812**. The coil of active electrode **822** may be preformed memory metal or a continuous wire which is looped on distal tip **812**.

[0061] **FIG. 8A** is a cross-sectional view showing coil active electrode **822** on distal end **812**. The outermost portion of coil active electrode **822** defines energy application surface **820** which forms both an energy treatment surface through the delivery of energy and a mechanical grating surface. Electrode **822** is preferably electrically connected through shaft **827** to the power source through conductor **816**. Electrode **822** is in the form of a ring on the distal tip and defines aspiration aperture **825**. Insulative material **830** lines aspiration lumen **850** to provide both electrical insulation from any stray electrical current and thermal insulation of the shaft. Return electrode **824** is located internally within aspiration lumen **850** and is electrically isolated from the active electrode **822** by insulator **828** and insulation material **830**. Return conductor **826** connects the return electrode **824** to the power source (not shown) at proximal end **814**.

[0062] In this configuration, the internal return electrode **824** forms a small boiling chamber whereby any matter being aspirated through aperture **825** and past active elec-

trode **822** increases the impedance to increase the delivery of energy in the region between the electrodes. As the energy output from the power source increases in response to the change in impedance, any matter located between the electrodes is ablated to prevent blockage of the aperture **825** and facilitate aspiration through aspiration lumen **850**. As smaller matter and debris and any excess fluid pass freely through aperture **825** and between the electrodes, the flow of material cools both electrodes to prevent any hot spots or unwanted ablative treatment effect.

[**0063**] Further, the internal return electrode **824** may provide a benefit of localized heating within the distal end **812** of the surgical instrument **810**. As the suction force is applied through aspiration lumen **850** and fluid and surgical by-products flow through aperture **825**, a pulling force is created within the local environment surrounding the distal end **812** and active electrode **822**. Similar to the blockage and cooling described above, the high intensity energy delivery is limited to an area in close proximity to the aperture **825**. Thus, ablation and other surgical procedures can be more precise since energy delivery is limited to the area immediately surrounding aperture **825**. The surgeon can control the treatment by direct placement of distal end **812** and electrode **822** on the biological tissue and limit the ablative effect to the tissue.

[**0064**] **FIGS. 9A and 9B** illustrate another alternative embodiment of electrosurgical instrument **810** having an active electrode **922** in the form of a ring electrode on distal tip **812**. The ring electrode configuration of active electrode **922** may be preformed memory metal or a solid metal tip on distal tip **812**. Electrode **922** is formed of any biocompatible material including stainless steel, tungsten, titanium or any of its respective alloys.

[**0065**] **FIG. 9A** is a cross-sectional view showing ring active electrode **922** on distal tip **812**. The outermost portion of the ring active electrode **922** defines energy application surface **820** which forms both an energy treatment surface through the delivery of energy and a mechanical smoothing surface. In this embodiment, the rounded surface provides a more diffuse energy application surface than electrode **822** of **FIG. 8**. This provides a surgeon with the ability to sculpt the body tissue by smoothing irregular areas by passing the curved electrode **922** over the tissue. The electrode **922** may also be formed into a sharp edge to provide a mechanical scraping surface for the removal of unwanted tissue. The electrical current is then crowded for maximum ablative effect along the sharp edge. Electrode **922** is preferably electrically connected through shaft **827** to the power source through conductor **816**. Electrode **922** is in the form of a ring on the distal tip and defines aspiration aperture **825**. Insulative material **830** lines aspiration lumen **850** to provide both electrical insulation from any stray electrical current and thermal insulation of the shaft. Return electrode **824** is located internally within aspiration lumen **850** and is electrically isolated from the active electrode **922** by insulator **828** and insulation material **830**. Return conductor **826** connects the return electrode **824** to the power source (not shown) at proximal end **814**.

[**0066**] **FIG. 9B** is an end view of the distal tip of the instrument of **FIG. 9A**. Active electrode **922** is shown as a ring around the aspiration lumen to define aperture **825**. Return electrode **824** is shown within the aspiration lumen and is electrically isolated from the active electrode **922** by insulator **828**. Internal return electrode **824** functions to form a boiling chamber as described above.

[**0067**] **FIGS. 10A and 10B** illustrate another alternative embodiment of electrosurgical instrument **810** having an active electrode **1022** in the form of a double prong on distal tip **812**. The double prong configuration of active electrode **1022** may be preformed memory metal or a solid metal partial loop or coil on distal tip **812**. Electrode **1022** is formed of any biocompatible material including stainless steel, tungsten, titanium or any of its respective alloys.

[**0068**] **FIG. 10A** is a cross-sectional view showing prong active electrode **1022** within insulator **828**. The prong is preferably fixed within insulator **828** such that one end is fixed within the insulator **828** and a portion of the prong passes over aperture **825** to fix into the opposite side of the insulator **828**. The outermost edge portion of the prong active electrode **1022** defines energy application surface **820** which forms both an energy treatment surface through the delivery of energy and a mechanical treatment surface. In this embodiment, a rounded prong surface provides a smoothing function as described above. The prong active electrode **1022** may also be formed into a sharp edge to provide a mechanical scraping surface for the removal of unwanted tissue. The electrical current is then crowded for maximum ablative effect along the sharp edge. Electrode **1022** is preferably electrically connected through shaft **827** to the power source through conductor **816**. Insulative material **830** lines aspiration lumen **850** to provide both electrical insulation from any stray electrical current and thermal insulation of the shaft. Return electrode **824** is located internally within aspiration lumen **850** and is electrically isolated from the active electrode **1022** by insulator **828** and insulation material **830**. Return conductor **826** connects the return electrode **824** to the power source (not shown) at proximal end **814**.

[**0069**] **FIG. 10B** is an end view of the distal tip of the instrument of **FIG. 10A**. Active electrode **1022** is shown as a prong passing over aperture **825**. In this embodiment, two prongs pass over the aperture **825** to prevent blockage of the aperture. Both electrode prongs are electrically connected to the power source through a single conductor **816** such that equal power is transmitted to active electrode **822** at the same time for equal effect. It will be appreciated that any number of prongs and the configurations may be use. Return electrode **824** is shown within the aspiration lumen and is electrically isolated from the active electrode **922** by insulator **828**.

[**0070**] FIGS. **11**A-C illustrate yet another embodiment of the present invention in which the active electrode **1122** is formed from a portion of shaft **1127**. **FIG. 11A** shows a distal end **1112** with active electrode **1122** forming an energy application surface **1120** for treatment of body tissue at a surgical site. At proximal end **1114**, conductor **1116** connects the shaft to electrically activate the active electrode **1122**. Return electrode **1124** is located externally to shaft **1127** and is electrically isolated from the active electrode **1122** by insulator **1128**. Preferably, return electrode **1124** is in the form of a ring electrode around a circumference of the shaft **1127**. Return conductor **1126** connects return electrode **1124** to the power source. The return electrical path may also be located on the patient's body as discussed previously. Shaft

insulation **1134** covers shaft **1127**. The interior suction lumen **1150** may also be lined with an insulative material.

[**0071**] An alternate embodiment of the active as shown in **FIG. 11B** is similar to the electrosurgical aspiration instrument of **FIG. 11A** where like elements are described with the same reference numbers. In this configuration, active electrode **1122** has cutouts **1129** to form a grating surface with cutout edges **1180**. By configuring the active electrode with cutout edges, the active electrode **1122** forms high current densities at the energy application surface **1120** such that current is crowded at the edges **1180**. Thus, maximum ablation in combination with a mechanical cutting and grating effect is achieved. Additionally, fluid may be delivered through the lumen to be delivered to the site when connected to a fluid delivery source and aspirated through the same lumen **1150** when connected to a suction source.

[**0072**] **FIG. 11C** illustrates a perspective view of the electrosurgical instrument of **FIG. 11B**. Edges **1180** protrude beyond the shaft and insulator **1128** for both delivery of treatment energy for ablation, cutting or coagulation and mechanical scraping for removal of unwanted tissue. As the current is crowded at the edges **1180**, the mechanical scraping and cutting is facilitated by providing an ablative effect at a precise cutting point along the tissue. In this embodiment, the treated tissue is then aspirated through the aspiration lumen away from the surgical site.

[**0073**] **FIGS. 12A and 12B** illustrate another embodiment of the present invention in which the active electrode is formed into a cross-shape with aspiration provided through and around the arm extensions. **FIG. 12A** shows a cross-section view of the active electrode **1222** of electrosurgical instrument **1210**. The active electrode **1222** is located at the distal end **1212** of shaft **1227** of instrument **1210**. Shaft **1227** may be covered by shaft insulation **1234**. Active electrode **1222** is connected to a power source (not shown) by electrical conductor **1216**. The arm extensions of active electrode **1222** are mostly planar with the main body of the electrode and extend outward to form edges **1280**. Apertures **1225** are formed between the arms of active electrode **1222**. A middle portion of active electrode **1222** may also be raised from the main body to form a middle edge **1280**. By raising edges **1280**, the current is crowded along the edges for increased electrical density at edges **1280** for an ablative effect. Edges **1280** may also be configured and sharpened for a simultaneous mechanical scraping and grating effect at the surgical site.

[**0074**] The placement of edges **1280** also prevents blockage of the apertures **1225** as current is delivered to the active electrode. As the current is crowded along edges **1280**, any matter resulting from the surgical site which is blocking the aperture **1225** increases the impedance between edges **1280** causing an increase in power. As the power increases, the treatment energy ablates the unwanted matter into a smaller size to pass through the aperture. For example, if unwanted matter blocks one quadrant of the aperture **1225**, impedance is increased along edge **1280** near the blockage. Since the force of suction is equal through the apertures, the suction unequally increases at the other quadrants thereby pulling the blockage along various axial planes. The increased treatment energy delivery ablates portions of the blockage to a point in which the unwanted matter moves easily through any of the apertures. This effect is similar to the mesh configuration of **FIG. 1** in which the ablative effect due to the electrode design across the aspiration aperture opening assists in further ablation of any blockage or unwanted material. The differential suction over the other non-blocked apertures creates a differential axial aspiration effect thereby assisting in removing the blockage.

[**0075**] Return electrode **1224** is located internally within aspiration lumen **1250** to form a boiling chamber as described above. The electrical energy is returned to the power source from return electrode **1224** by return conductor **1226**. The return electrode **1224** is electrically insolated from active electrode **1222** by insulator **1228**.

[**0076**] **FIG. 12B** is a perspective view of the instrument **1212** of **FIG. 12A**. In this embodiment, edges **1280** are raised to form a cup or pocket for ablation. Edges **1280** function as both a mechanical cutting surface edge and a current crowding edge for effective ablation.

[**0077**] Another embodiment is illustrated by **FIG. 13A** in which electrosurgical instrument **1310** has an ashtray configuration of the active electrode **1322**. Active electrode **1322** is located on the distal end **1312** of shaft **1327**. The instrument shaft may be covered with shaft insulator **1334**. Active electrode **1322** is in an ashtray configuration where cutouts **1329** are formed in energy application surface **1320**. By forming cutouts **1329**, edges **1380** are formed within the energy application surface **1320** of active electrode **1322**. Edges **1380** form both a mechanical tissue removal surface simultaneously with a current crowding edge for maximum energy delivery effect. Blockage of aperture **1325** can also be prevented and eliminated by configuring active electrode **1322** with edges **1380** near the aperture **1325**. Electrical conductor **1316** electrically couples the electrode **1322** to the power source (not shown). Active electrode **1322** is configured with a central aperture **1325** which communicates with aspiration lumen **1350**. Return electrode **1324** is located within aspiration lumen **1350** and is proximal to active electrode **1322** to form a boiling chamber as described above. Insulator **1328** insulates electrodes **1322** and **1324**. An internal lining **1330** may also line aspiration lumen **1350** to function as both an electrical and thermal insulator.

[**0078**] **FIG. 13B** is a perspective view of **FIG. 13A** in which the active electrode **1322** is show in the ashtray configuration. Cutouts **1329** within the electrode define edges **1380** for the mechanical and electrical effect as described above. Aperture **1325** communicates through instrument **1310** with aspiration lumen **1350**.

[**0079**] **FIG. 14A and 14B** illustrate cross-sectional and perspective views of an alternative embodiment of the electrosurgical aspiration instrument **1310** as described **FIGS. 13A and 13B**. Similar elements will be referenced to **FIGS. 13A and 13B**. In this embodiment, return electrode **1424** is located external along the shaft **1327**. Return electrode **1426** electrically completes the current path to the power source from the active electrode **1322**. The return electrode **1424** is preferably a ring electrode located on the surface of shaft **1327** and is isolated from the active electrode **1322** by insulator **1328**.

[**0080**] FIGS. **15**A-C illustrate different views of ashtray electrode according to one alternative embodiment of the active electrode as described above. Like elements will be referenced by the same reference numbers. **FIG. 15A** shows

a close-up perspective view of active electrode **1522** in which at least one aperture **1525** is provided through active electrode **1522**. Active electrode **1522** is configured to crowd the current creating a high current density along a circumferential edge **1580**. Edge **1580** defines energy application surface **1520**. Cutouts **1529** form a pattern along edge **1580** to maximize the current crowding. As the current is crowded along edges **1580**, a mechanical scraping and ablative effect occurs simultaneously. Current is also crowded edge **1580** formed within aperture **1525** to prevent blockage of the aperture. As energy is applied to the active electrode, the sharp edge of surface **1580** provides both a surface for the delivery of RF power for ablation while simultaneously providing a mechanical grating or scraping surface for scraping tissue at the surgical tissue site. It will be appreciated that edge **1580** of electrode **1520** may be rounded such that a smoothing surface may be formed and sculpting may be performed with the instrument of the present invention.

[**0081**] As by-products of ablation and/or coagulation are created at the surgical site, negative pressure created by suction through the lumen and electrosurgical instrument aspirates the additional matter through aperture **1525**. However, blockage and clogging of the aperture **1525** may undesirably increase the ablation effect by reducing the flow of liquid and tissue through aperture **1525**. By-products of surgery such as biological tissue debris could result from the ablation and cutting process. As this matter becomes dislodged and freely movable within the surgical site, the biological tissue may completely block any and all apertures into the instrument. Thus, the cooling effect due to the flow of matter and liquid is reduced thereby increasing the delivery of treatment energy to the site possibly causing unnecessary ablation and injury to the patient.

[**0082**] To combat blockage and potential injury, edges **1580** may be configured with reference to **FIG. 12** wherein a portion of edges **1580** is configured and positioned near or within aperture **1525**. As the impedance increases due to blocked tissue within aperture **1525**, the tissue is further treated with energy at edges **1580** whereby the tissue is further ablated to a size to fit through aperture **1525**. The irregular shape of aperture **1525** in combination with edges **1580** provides for non-uniform and non-round apertures such that both an electrical and mechanical effect combine to prevent blockage within the opening thereby increasing the efficiency of the electrosurgical instrument **1510**.

[**0083**] **FIG. 15B** shows an end view of the distal electrode tip **1512**. Energy application surface **1520** and edge **1580** are shown with cutouts **1529**. It will also be appreciated that the number, sizes and placement of cutouts **1529** within surface **1520** may vary to provide different ablation effects and patterns. The electrical current is crowded and has the greatest density at surface **1520** and edge **1580** such that ablation, cutting and/or coagulation occurs along edge **1580**.

[**0084**] **FIG. 15C** is a cross-sectional view of the distal tip of **FIG. 15B** in which the active electrode **1522** on distal end **1512** is shown along Line A-A. The energy application surface **1520** is shown in detail as a sharp edge **1580** with both an electrical effect for ablation and mechanical effect for scraping. Edge **1580** is shown to be intruding into a portion of aperture **1525** which leads to aspiration lumen **1550**. With reference to **FIG. 12** above, the effect of suction through a non-uniform configuration of aperture **1525** prevents the blockage and clogging of the aspiration opening such that the negative pressure pulls the blockage into the lumen across different axial planes. For example, as an unwanted by-product matter hits aperture **1525**, it lodges on a portion of edge **1580**. As the suction is applied to the lumen and through the opening, a portion of the matter is pulled on the portions away from the lodged portion along edge **1580**. This allows the matter to twist and turn in different axial planes whereby the unwanted matter moves and has a different and more compatible physical orientation to move through aperture **1525**.

[**0085**] **FIGS. 16A and B** illustrate a further alternative embodiment of the present invention in which the active and return electrodes **1622**, **1624** lie in substantially the same plane of the energy application surface **1620** at the distal end **1612** of instrument **1610** to define a true bipolar configuration. Such position of electrodes **1622** and **1624** may be accomplished by forming each electrode as an arcuate element positioned on the distal end **1612** of instrument **1610**. Electrodes **1622** and **1624** are supported by insulator **1628** which serves the additional function of electrically isolating electrodes **1622** and **1624**. Cutouts **1629** are formed in insulator **1628** to space apart and thus further electrically isolate electrodes **1622** and **1624**. Central opening **1625** allows for aspiration.

[**0086**] Electrodes **1622** and **1624** are separately coupled to the power source by separate respective conductive elements **1616** and **1626**. Conductive elements preferably extend from distal end **1612** to proximal end **1614** of instrument **1610** through lumen **1650**. Although conductive elements **1616** and **1626** extend through the central opening **1625** through insulator **1628** to be coupled with electrodes **1622** and **1624** on the distal-most end of insulator **1628**, it will be appreciated that other arrangements are also within the scope of the present invention. For instance, conductive elements **1616** and **1626** may extend through a passage formed through insulator **1628** to communicate lumen **1650** with electrodes **1622**, **1624**. Lumen **1650** may be used for aspiration as previously described.

[**0087**] It will be appreciated that the above-described arrangements that provide an energy application surface area at the distal tip of the electrosurgical instrument may be applied to an instrument that is not capable of aspiration. Thus, insulator **1628** of instrument **1610** may be a substantially solid element with passages therethrough for the purpose of electrically coupling electrodes **1622** and **1624** to the power source but not for aspiration purposes. The arrangement of the active and return electrodes may be further modified as in **FIGS. 10 and 11** to provide and energy application surface area that, although contoured (i.e., not completely planar), still remains at the distal end of the instrument, substantially transverse to the longitudinal axis, without extending along a distal portion of the side walls of the instrument (such as in instrument **10** of **FIGS. 1 and 2**).

[**0088**] **FIGS. 17A and 17B** illustrate another embodiment of the electrosurgical aspiration instrument **1710** of the present invention in which the active electrode **1722** and the return electrode **1724** are comparably sized and located in close proximity to each other at the distal end **1712**. This arrangement of electrodes **1722** and **1724** define a true

bipolar configuration. Active electrode **1722** is a single disc shaped electrode which is centrally located at distal end **1712** within insulator **1728**. Return electrode **1724** is a ring electrode located substantially along the same plane at the circumferential edge of insulator **1728**. The effective area size of both electrodes are similar such that the delivered treatment energy is equal between both electrodes. Apertures **1725** are located within insulator **1828** and communicates with aspiration lumen **1750**. As the ablation, cutting and coagulation occur at the active electrode **1722**, the suction applied to the aspiration lumen forces the by-products and excess fluid through apertures **1725**.

[**0089**] **FIG. 17B** shows a cross-sectional view in which the active electrode **1722** is coupled to a power supply (not shown) at the proximal end **1714** by power conductor **1716**. Return electrode **1724** is coupled to electrically conductive shaft **1727** by extension **1736** to complete the circuit to the power supply. Shaft **1727** is covered by shaft insulation **1734**.

[**0090**] FIGS. **18**A-C illustrate a further alternative embodiment of the electrosurgical aspiration instrument **1810** of the present invention in which the active and return electrodes **1822**, **1824** lie in the same plane at the distal end **1812**. The active and return electrodes are substantially configured similarly such that the two conductors **1816** and **1826** are electrically coupled through shaft **1827** to the distal end **1812**. Electrodes **1822** and **1834** are electrically isolated by insulator **1828**. Delivery of energy is equal to both electrodes such that an equal, bipolar effect occurs at the surgical site. Both electrodes extend from one side of aspiration aperture **1825** to a point across the aperture and return to the generator. One electrode serves as an active electrode and one electrode serves as a return electrode. It will be appreciated that either electrode may be an active or a return since the polarity of the power generator may be reversed. Because both electrodes are configured across the aspiration aperture **1825**, clogging and blockage of the aperture is prevented or reduced.

[**0091**] **FIG. 19** illustrates a perspective view of an electrosurgical aspiration instrument **1910** according to the present invention. Aspiration line **1952** is attached to proximal handle **1917**. Aspiration line **1952** connects to a suction device and receptacle (not shown) which provides a negative pressure through the instrument in order to aspirate ablation by-products through distal tip **1912** through probe shaft **1927**. A power receptacle **1914** connects instrument **1910** to a power source (not shown). An actuator **1918** controls the amount and force of suction through the aspiration line **1952** and is controlled by a roller. Vacuum line connector **1957** connects to the aspiration receptacle. It will be appreciated that any device or mechanism to control the amount and force of suction may be used to aspirate surgical material through the instrument **1910**.

[**0092**] **FIGS. 20 and 21** show two alternative embodiments of the distal end **1912** of **FIG. 19** of the present invention in which the shaft **1927** of distal end **1912** is pre-bent. As discussed above, it is preferable that the shaft **1927** is not flexible such that the aspiration lumen is not pinched nor crimped thereby blocking suction. The reduction of the suction force as discussed above may lead to an increase in the ablation effect. **FIG. 20** shows a 30 degree bend in distal end **1912** and **FIG. 21** is a 90 degree bend. While the degree of pre-bent angle is not limited to these specific degrees, it will be appreciated that the manufacture of the pre-bent distal end **1912** be optimized for access to a particular body position or part for a desired surgical procedure and corresponding ablation effect. For example, the 90 degree bend in distal end **1912** as shown in **FIG. 21** allows access to areas such as the subacromial space under the acromium in the shoulder. This allows for better access by a surgeon to the particular body part.

[**0093**] The embodiments of the electrosurgical instrument of the present invention that permit an aspiration function in combination with an electrosurgical function are particularly useful for surgical procedures requiring ablation of tissue or other body parts. In order to perform an ablation function, the energy supplied to the electrosurgical aspiration instrument should be in the range of 100-500 KHz. This range may be varied depending on the materials used to form the instrument as well as depending on the particular application of the instrument in the surgical procedure. The lowest frequency used typically is selected such that use of the instrument does not interfere with other tissue nor stimulate nerves in the area, etc. Thus, isolated treatment of the selected tissue area is permitted. The highest frequency used typically is limited depending on the desired results that would be achieved by such frequency. For instance, at too high a frequency, appropriate ablation may not be achievable and blockage of the lumen by debris may occur.

[**0094**] Power may be provided by commercially available RF energy sources. Such RF energy sources may include generators which control the temperature of the electrosurgical instrument. Power may also be regulated by feedback to prevent overpower and undesired ablation or coagulation as such.

[**0095**] As mentioned above, the electrosurgical instrument of the present invention may be used for any of a variety of applications and procedures, depending on the nature of the energy supplied thereto by the power source. It will, therefore, be appreciated that the energy supplied to the electrosurgical instrument of the present invention may be varied depending on the application desired. The energy level may even be varied during use to perform a variety of functions, such as ablation followed or accompanied by cauterization or coagulation as necessary.

[**0096**] While the foregoing description and drawings represent the preferred embodiments of the present invention, it will be understood that various additions, modifications and substitutions may be made therein without departing from the spirit and scope of the present invention as defined in the accompanying claims. In particular, it will be clear of those skilled in the art that the present invention may be embodied in other specific forms, structures, arrangements, proportions, and with other elements materials, and components, without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims and not limited to the foregoing descriptions.

What is claimed is:

1. A surgical instrument, comprising:

a shaft having distal and proximal ends, said shaft defining at least one lumen having at least one aspiration opening at said distal end;

an active electrode disposed at the distal end of said shaft, said active electrode defining an energy application surface and electrically coupled to a power source; and

a return electrode coupled to the power supply such that a current path from said active electrode to said return electrode passes over said aspiration opening.

2. The surgical instrument of claim 1, wherein negative pressure applied to said lumen causes matter to be aspirated through said aspiration opening.

3. The surgical instrument of claim 1, wherein said aspiration lumen comprises at least one opening at said distal end that is configured to prevent clogging of aspirated matter at said distal end.

4. The surgical instrument of claim 3, wherein said aspiration opening is defined by said active electrode.

5. The surgical instrument of claim 4, wherein said aspiration opening is configured to provide an electrical and mechanical effect.

6. The surgical instrument of claim 1, wherein said active electrode defines a current crowding edge energy application surface.

7. The surgical instrument of claim 1, wherein said active electrode defines a substantially planar external energy application surface.

8. The surgical instrument of claim 1, wherein said active electrode comprises a mesh having interstices in communication with said aspiration lumen such that aspiration may occur through said interstices of said active electrode.

9. The surgical instrument of claim 8, further comprising a ring of conductive, non-perforated material surrounding said mesh and providing structural support thereto.

10. The surgical instrument of claim 1, wherein said active electrode comprises a disc surface having perforations formed therethrough, said perforations permitting aspiration to occur through said active electrode.

11. The surgical instrument of claim 1, wherein said active electrode is concentrically disposed at said distal end of said shaft to define an energy application surface.

12. The surgical instrument of claim 11, wherein the return electrode is located on an exterior body tissue site.

13. The surgical instrument of claim 11, wherein said return electrode is formed as a ring around the distal end of said shaft and said active electrode is disposed within said ring.

14. The surgical instrument of claim 1, wherein said active and return electrodes are connected to first and second conductors, respectively.

15. The surgical instrument of claim 14, wherein one of said first and second conductors is formed from said shaft.

16. The surgical instrument of claim 15, wherein the proximal end of said shaft is mounted to a handle, said handle providing at least one connection for said conductor to a power supply and a connection for said aspiration lumen to a vacuum source.

17. A surgical instrument, comprising:

a shaft having distal and proximal ends, said shaft defining at least one aspiration lumen extending therethrough and having an aspiration opening at said distal end;

an active electrode disposed at said distal end of the shaft, said active electrode defining an energy application plane across said aspiration opening and having a plurality of openings therethrough communicating with the aspiration lumen such that material may be aspirated through said active electrode across said energy application plane, said plurality of openings being individually sized and configured to avoid clogging of aspirated matter downstream of said openings; and

a return electrode electrically coupled to said power source.

18. The surgical instrument of claim 17, wherein said return electrode is located external to the surgical site on a patient's body.

19. The surgical instrument of claim 17, wherein said return electrode is disposed on said shaft proximally from said active electrode.

20. The surgical instrument of claim 17, wherein said active electrode comprises a mesh having interstices which define said plurality of openings in communication with said lumen such that aspiration may occur through said interstices of said mesh.

21. The surgical instrument of claim 17, wherein said active electrode comprises a disc having perforations therethrough to form said plurality of opening such that aspiration may occur through said perforations.

22. A surgical instrument, comprising;

a shaft having distal and proximal ends, said shaft defining an aspiration lumen having a diameter extending therethrough and having an opening at said distal end;

a conductive member disposed at said distal end of said shaft across said aspiration lumen to define an energy application plane across said lumen opening and forming an active electrode, said conductive member having at least one opening therethrough communicating with the aspiration lumen such that material may be aspirated through said active electrode across said energy application plane, said opening being individually smaller than said lumen diameter to avoid clogging of aspirated material downstream of said opening;

a first conductor connected to said conductive member;

a return electrode disposed around said shaft proximally from said active electrode; and

a second conductor connected to said return electrode.

23. The surgical instrument of claim 22, wherein one of said first and second conductors is formed by said shaft.

24. The surgical instrument of claim 22, wherein said lumen has an insulative coating.

25. The surgical instrument of claim 22, wherein said conductive member is a disc.

26. The surgical instrument of claim 22, wherein said conductive member is an ashtray.

27. A surgical instrument, comprising:

a shaft having a proximal end and a distal end with a longitudinal axis;

an active electrode and a return electrode disposed on the distal end and connected to the distal end to define an energy application surface at said distal end generally transverse to said longitudinal axis; and

a connector disposed near said proximal end of said shaft for electrically coupling said electrodes to a power source such that a voltage may be applied between each of the electrodes.

28. The surgical instrument of claim 27, wherein said active electrode and return electrode lie in substantially the same plane to define a planar energy application surface at said distal end.

29. The surgical instrument of claim 27, wherein a first of said electrodes is disposed centrally on the distal end of said shaft and the second of said electrodes is a ring disposed around the first electrode.

30. The surgical instrument of claim 27, wherein said electrodes are arcuate in shape and are each disposed around a portion of the distal end of the shaft, lying in substantially the same plane approximately transverse to the longitudinal axis.

31. The surgical instrument of claim 27, wherein said shaft defines an aspiration lumen therethrough and the distal end of the shaft defines at least one opening between said active and return electrodes communicating with the aspiration lumen for aspirating material through the energy application surface.

32. The surgical instrument of claim 31, wherein the active electrode is located on a distal tip portion of the distal end and the return electrode is located on an internal portion of the aspiration lumen and proximal to the active electrode.

33. The surgical instrument of claim 31, wherein said first electrode and second electrode are electrically isolated.

34. The surgical instrument of claim 27, wherein said shaft is substantially cylindrical having a periphery and said arcuate electrodes are disposed on the periphery of said shaft and the distal end, said electrodes being separated by at least one notch in said shaft.

35. The surgical instrument of claim 27, wherein said shaft defines an aspiration lumen therethrough and said distal end of the shaft defines at least one opening between the active electrode and the return electrode communicating with said aspiration lumen for aspirating matter through said energy application surface.

36. A method of electrosurgically treating tissue at a surgical site, comprising:

positioning an energy application surface adjacent or in contact with tissue to be treated;

applying energy across said application surface to the treatment area;

aspirating matter generation as a result of the energy application through the energy application surface; and

applying energy to the aspirated materials passing through the energy application surface.

37. The method of claim 36, wherein said energy is radiofrequency energy.

38. The method of claim 36, wherein said energy application surface is formed on the distal end of a surgical instrument.

39. The method of claim 36, wherein said energy application surface is defined by an active electrode.

40. The method of claim 36, wherein said aspirating step occurs over a non-uniform plane creating a differential suction of a blockage across the energy application surface to facilitate aspiration of the blockage through the energy application surface.

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