

electrodes for RF energy. This arrangement may take advantage of the fact that the active and return electrodes are in close proximity to one another, thus setting up a preferential return path to enable local tissue cutting action to take place without the need for a remote return pad or a highly conductive liquid, i.e. saline, existing between the two electrodes.

In this example, the RF cutting portion may comprise a RF voltage source coupled to the planar transmission line, a frequency diplexer/duplexer unit (or signal adder) comprising a low pass filter to prevent the high frequency microwave energy from going back into the lower frequency RF energy source and a high pass filter to prevent the lower frequency RF energy from going back into the higher frequency microwave energy source. In one example, the frequency diplexer/duplexer may be used to enable the microwave and RF energy sources to be combined at the generator and delivered along a single channel, e.g. co-axial cable, waveguide assembly or twisted pair, to the spatula structure. The RF cutting energy may be delivered alone into the tissue or it may be mixed or added with the microwave energy and delivered simultaneously to set up a blended mode of operation.

SUMMARY OF THE INVENTION

The present invention develops further the spatula concept discussed in GB 2 472 972 and the manner with which it interfaces with a generator that provides RF and/or microwave energy for treatment.

In a first aspect, the invention provides an Described herein is a further optimised configuration for the distal end of an electrosurgical tool for controlled resection of biological tissue.

In a second first aspect, the invention provides an interface joint for integrating into a single cable assembly all of (i) a fluid feed, (ii) a needle movement mechanism, and (iii) an energy feed (e.g. a cable supplying RF and/or microwave energy). The cable assembly may be sized to fit through the instrument channel of a conventional endoscope.

In a third aspect, the invention provides Also described herein is a torque transfer device for permitting controlled rotation of the

cable assembly within the instrument channel of the endoscope. The interface joint and torque transfer device may be integrated as a single component.

According to the first aspect of the invention, there is provided Described herein is an electrosurgical instrument for applying to biological tissue radiofrequency (RF)

5 electromagnetic (EM) energy and/or microwave frequency EM energy, the instrument comprising: an instrument tip comprising a planar body made of a first dielectric material separating a first conductive element on a first surface thereof from a second conductive element on a second surface thereof, the second surface facing in the opposite direction to the first surface; a coaxial feed cable comprising an inner conductor, an outer conductor
10 coaxial with the inner conductor and a second dielectric material separating the inner and outer conductors, the coaxial feed cable being for conveying an RF signal and/or a microwave signal; and a protective hull comprising a third piece of dielectric material mounted to cover the underside of the planar body, wherein the inner conductor is electrically connected to the first conductive element and the outer conductor is electrically
15 connected to the second conductive element to enable the instrument tip to receive the RF signal and/or the microwave signal, wherein the protective hull has a smoothly contoured convex undersurface facing away from the planar body, wherein the planar body has a tapering distal edge, and wherein the underside of the planar body extends beyond the protective hull at the tapering distal edge. This combination of features represents an optimal
20 configuration that balances the accuracy of treatment at the distal tip (which is enhanced due to the extension of the planar body over the protective hull) with the ease of safe manipulation of the instrument (due to the protective hull itself).

The portion of the underside of the planar body that extends beyond the protective hull at the tapering distal edge may be termed the extension zone. The extension zone may
25 be uniform around the perimeter of the tapering distal edge. Alternatively, the extension zone itself may taper in width towards the distal tip of the planar body. The tapering may be between a minimum value at the distal tip and a maximum value at the proximal end of the tapering distal edge. There may be zero extension at the distal tip, i.e. the protective

frequency EM energy in this case depends on the overall shape of the planar body and the microwave feed structure. In this particular instance, the gap at the proximal end between the co-axial feed line (centre conductor) and the upper conductive layer plays an important role in ensuring that the microwave energy from the source is matched in terms of

impedance with the load impedance presented by the tissue. The overall length of the planar transmission line arrangement is also important in terms of matching the impedance (or the energy delivery) of (or from) the coaxial transmission line with (or into) the biological tissue, i.e. the structure may form a quarter wave impedance transformer or a half wavelength resonator. Using known simulation tools, this may be modelled to control from which edges the microwave frequency EM energy is radiated. For example, the instrument tip may be configured to inhibit radiation of the microwave EM radiation from a distal edge of the planar body.

The tapering distal edge may have any suitable profile, e.g. obtained by computer modelling the device in particular use configurations. The tapering distal edge may be curved or straight or a combination of the two. For example, the tapering distal edge may comprise a straight taper terminated in a curved distal tip, e.g. a single radius curved distal tip. The tapering distal edge may extend around a distal third of planar body. In one embodiment, the curved distal edge may have a curvature formed from a plurality of contiguous radiused sections, each radiused section having a radius of curvature less than its proximal neighbour. There may be three or more sections of different radii. The plurality of contiguous radiused sections may be arranged to give the curved distal edge a quasi parabolic shape.

As mentioned above, the width of the planar body may be dictated by the intended use for the instrument. In endoscopic procedures, the width may be 2 mm or less, whereas for other less restrictive procedures the width may be up to 9 mm, e.g. any of 8 mm or less, 7 mm or less, 6 mm or less, 5 mm or less, 4 mm or less or 3 mm or less.

The length of the planar body (including the tapering distal end) may be related to, e.g. in proportion with, its width in order to deliver the RF and/or microwave frequency energy most efficiently. The length of the planar body may

thus be about $5w$, e.g. between $5w$ and $6w$, preferably $5.3w$ where w is the maximum width of the planar body.

~~In one embodiment, the planar body has a maximum width of 2 mm and a maximum length of 10.6 mm. In this embodiment, the tapering distal edge may comprise a plurality of contiguous radiused sections consisting of a first radiused section having a length of 1.6 mm and a radius of curvature of 12.4 mm, a second radiused section having a length of 1.0 mm and a radius of curvature of 10.2 mm, a third radiused section having a length of 0.7 mm and a radius of curvature of 3.2 mm, a fourth radiused section having a length of 0.2 mm and a radius of curvature of 0.85 mm, and a fifth radiused section having a length of 0.1 mm and a radius of curvature of 0.35 mm.~~

The first and second conductive elements may each comprise a layer of metallisation, the layers of metallisation being formed on opposite surfaces of the first dielectric material. The layers of metallisation may be set back (e.g. by 0.2 mm) from the side edges of the first dielectric material in a proximal region of the planar body, to reduce the field strength at this region. The proximal region may comprise the region of the planar body proximal to the curved distal end. This may help concentrate the energy delivery at the distal end. The inner conductor and outer conductor may contact the first and second conductive elements in a coaxial manner, i.e. the first and second conductive elements may be shaped to be symmetric about an axis running along the planar body from the coaxial feed cable.

The undersurface of the protective hull may smoothly taper at its perimeter to meet the underside of the planar body. The thickness of the protective hull may also decrease towards the distal end of the instrument tip. Thus, the outer-portion of the protective hull may have a convex profile. The undersurface may have a longitudinally extending recessed channel formed therein. The tapering edge profile and recessed channel may cause the undersurface of the protective hull to comprise a pair of ridges. The tapered conformal flowing form of the hull may reduce the risk of the instrument digging into collateral tissue aiding its ability to glide. For example, this shape may reduce the risk of the instrument

digging into the bowel wall and causing a bowel perforation or may protect the portal vein or pancreatic duct from being damaged. The particular dimensions of the hull (e.g. length, width, thickness, etc.) may be adapted to suit the intended use and intended area of the body to be operated on.

5 The protective hull may be formed from a biocompatible non-conductive material, such as polyether ether ketone (PEEK), ceramic (e.g. alumina, zirconia or zirconia toughened alumina (ZTA)) or biocompatible plastic that does not stick to the wall of the bowel (or other biological tissue) or the like. Alternatively, the hull may also be formed from a metallic material, e.g. titanium, steel, or may be a multi-layer structure. It may be attached
10 (e.g. bonded) to whichever one of the first or second conductive elements is on the underside of the first dielectric material. However, in one embodiment, the protective hull may be formed of the same material as the first dielectric material. The protective hull and first dielectric material may be formed in one piece as a unitary body. In this arrangement one or more planar slots may be formed (e.g. cut) in the unitary body to allow a conductive
15 material to be inserted to form the first and/or second conductive material. The conductive material may be inserted by coating one or more internal surfaces of the slot. Alternatively or additionally, the protective hull may be selectively metallised to form part of the first or second conductive elements.

 The instrument may include a fluid feed conduit for delivering fluid (e.g. saline) to the
20 instrument tip. The fluid feed conduit may comprise a passageway through the protective hull for delivering fluid to the treatment site. The passageway may include an outlet located in the recessed channel of the protective hull. The coaxial feed cable may form part of a multi-lumen conduit assembly for delivering RF and/or microwave frequency energy and fluid (liquid or gas) to the instrument. The fluid (protective hull) may be conveyed through a
25 corresponding passageway formed within the multi-lumen conduit assembly. The fluid feed conduit may also be used to deliver other material to the treatment site, e.g. a gas or a solid (e.g. powder). In one embodiment example, injection of fluid (saline or the like) is used to plump up the biological tissue at the treatment site. This may be particularly useful

protective hull, e.g. on an undersurface thereof. The tip of the protrusion may have an outlet for a fluid passage, and thus may act as a fixed needle-like tip for fluid injection into the tissue. The tip of the cone may project slightly beyond the distal tip of the planer body.

According to the second first aspect of the invention, there is provided an interface joint for interconnecting an electrosurgical generator and an electrosurgical instrument (which may be an instrument according to the first aspect of the invention), the interface joint comprising: a housing made of electrically insulating material, the housing having: a first inlet for receiving radio-frequency (RF) electromagnetic (EM) energy and/or microwave frequency EM energy from the electrosurgical generator, a second inlet for receiving fluid, and an outlet; a single cable assembly for connecting the outlet to the electrosurgical instrument, the signal-single cable assembly comprising a flexible sleeve that defines a fluid flow path that is in fluid communication with the second inlet, and which conveys a coaxial cable that is connected to the first inlet.

The electrosurgical generator may be any device capable of delivery RF EM energy or microwave frequency EM energy for treatment of biological tissue. For example, the generator described in WO 2012/076844 may be used.

The electrosurgical instrument may be any device which in use is arranged to use RF EM energy or microwave frequency EM energy for the treatment of biological tissue. The electrosurgical instrument may use the RF EM energy and/or microwave frequency EM energy for any or all of resection, coagulation and ablation. For example, the instrument may be a resection device as disclosed herein, but alternatively may be any of a pair of microwave forceps, a snare that radiates microwave energy and/or couples RF energy, and an argon beam coagulator.

The housing may provide a double isolation barrier for the operator, i.e. the housing may comprise an outer casing (first level of isolation) that encapsulates a branched passageway (second level of isolation) within which the various inputs are integrated into the single cable assembly. The branched passageway may provide a watertight volume which defines a fluid flow path between the second inlet and the

element inside a single lumen tube. The extruded separator element may include a plurality of through channels (e.g. two, three or more). One of the through channels may carry the push rod (if present). The other channels may be left empty, which can ensure that there is always a open fluid flow path between the instrument and interface joint for guiding the coaxial cable and one or more through holes for carrying the fluid feed conduit and control wire(s). The fluid flow path may flood the internal cavity formed by the flexible sleeve, and the coaxial cable may be immersed in the fluid.

A distal end of the push rod may be connected to a proximal end of a needle ferrule, which has a needle clamped to its distal end. The ferrule may be hollow, with one or more openings in its outer wall that cause its interior to be in fluid communication with the fluid flow path through the flexible sleeve. The distal end of the ferrule may be open such that the needle mounted in the distal end is in fluid communication with the fluid flow path. The proximal end of the ferrule may be sealed by the push rod.

~~According to the third aspect of the invention, there is provided~~Also described herein is a torque transfer unit for rotating an electrosurgical instrument at the distal end of an endoscope by transferring a user's rotating force to a flexible sleeve connected to the electrosurgical instrument, wherein the torque transfer unit comprises an elongate clamp arranged to impart a gripping force along a length of the flexible sleeve that lies outside the endoscope, the elongate clamp comprising: an upper elongate housing member, a lower elongate housing member pivotably connected to the upper elongate housing member and defining a passage for the flexible sleeve, wherein the upper elongate housing member and the lower elongate housing member are pivotable between a release position in which the torque transfer unit is slidable up and down the flexible sleeve, and a clamping position, in which the flexible sleeve is gripped between the upper elongate housing member and the lower elongate housing member.

The torque transfer unit may thus be designed to slide freely along the length of the flexible sleeve to a position that is convenient for use. Once in position, the torque transfer unit can grip the sleeve by pivoting the upper elongate housing member and the lower elongate housing member

together. The torque transfer unit may include a releasable clip that allows the upper elongate housing member and the lower elongate housing member to be locked in place at any point. The clip may be a resilient latch element on one of the upper elongate housing member and the lower elongate housing member, which a corresponding catch on the other.

5 The upper elongate housing member and the lower elongate housing member may each carry a U-shaped clamping member, the U-shaped clamping members being arranged to oppose one another to impart a substantially uniform gripping pressure on the flexible sleeve when the upper elongate housing member and the lower elongate housing member are in the clamping position. ~~In a preferred embodiment, a~~ An intermediate deformable grip
10 tube ~~is~~ may be position around the flexible sleeve between the flexible sleeve and the U-shaped clamping members. The intermediate grip tube may be made of silicone or any other suitable compliant material. In use the intermediate deformable grip tube grips the flexible sleeve on compression and fixes the position of the torque transfer unit. The intermediate grip tube acts to distribute the load on the flexible sleeve which can prevent local damage to
15 the wall of the sleeve.

In use, when the distal tip of the electrosurgical instrument is correctly positioned relative to the distal end of the flexible endoscope within the field of view on the endoscope's video monitor, it is intended that the endoscopist clamps and locks the torque transfer unit at the exit point of the flexible shaft from the endoscope working channel and immediately
20 adjacent to the endoscope X-Y controls. When clamped in this location the torque transfer unit provides finger and thumb rotary and longitudinal positional control of the distal tip of the instrument. The variable positioning and clamping of the torque transfer unit allows the instrument to be used endoscopes of differing lengths (e.g. flexible endoscopes with working channels anywhere between 60 and 170 cm long).

25 Herein, radiofrequency (RF) may mean a stable fixed frequency in the range 10 kHz to 300 MHz and microwave frequency may mean a stable fixed frequency in the range 300 MHz to 100 GHz. The RF energy should have a frequency high enough to prevent the energy from causing nerve stimulation

and low enough to prevent the energy from causing tissue blanching or unnecessary thermal margin or damage to the tissue structure. Preferred spot frequencies for the RF energy include any one or more of: 100 kHz, 250 kHz, 400kHz, 500 kHz, 1 MHz, 5 MHz. Preferred spot frequencies for the microwave energy include 915 MHz, 2.45 GHz, 5.8 GHz, 14.5 GHz,
 5 24 GHz.

BRIEF DESCRIPTION OF THE DRAWINGS

Examples embodying the invention as discussed in detail below with reference to the
 10 accompanying drawings, in which:

Fig. 1 is a schematic view of a complete electrosurgery system in which the present invention is applied;

Fig. 2 is a cross-sectional view of an interface joint that is an embodiment of the invention;

15 Fig. 3 is a cut away perspective view of the interface joint shown in Fig. 2;

Fig. 4A is an exploded view of a torque transfer unit that is an embodiment of the invention;

Fig. 4B is a perspective view of the torque transfer unit of Fig. 4A in an assembled state;

20 Fig. 5 is a schematic perspective view of another interface joint that is an embodiment of the invention;

Fig. 6 is a schematic perspective view of an integrated interface joint and torque transfer unit that is an embodiment of the invention;

Fig. 7 is a schematic perspective view of another integrated interface joint and torque
 25 transfer unit that is an embodiment of the invention;

Fig. 8 is an exploded view of a distal end assembly for an electrosurgery device that is an embodiment of the invention;

Fig. 9A is a top perspective view of the distal end assembly of Fig. 8 in an assembled state;

30 Fig. 9B is a bottom perspective view of the distal end assembly of Fig. 8 in an assembled state;

Fig. 10 is a cross-sectional view of an interface cable suitable for use with the present invention;

Fig. 11A is a top view of a bipolar structure used in the distal end assembly of Fig. 8;

Fig. 11B is a side view of a bipolar structure used in the distal end assembly of Fig. 8;

Fig. 11C is a bottom view of a bipolar structure used in the distal end assembly of

Fig. 8;

Fig. 12A is view of a needle assembly suitable for use with the distal end assembly of

Fig. 8;

Fig. 12B is an enlarged cross-sectional view through the needle assembly shown in

Fig. 12A;

Fig. 13 is a schematic drawing illustrating a fluid flow path through an interface cable that is suitable for use with the present invention;

Fig. 14A is a top view of a protective hull used in the distal end assembly of Fig. 8;

Fig. 14B is a cross-sectional view through the protective hull used in the distal end assembly of Fig. 8;

Fig. 15A is a perspective view of a stopper used in the interface joint shown in Fig. 2;

Fig. 15B is a cross-sectional view through the stopper shown in Fig. 15A;

Fig. 16A is a perspective view of a Y-shaped connector used in the interface joint shown in Fig. 2;

Fig. 16B is a cross-sectional view through the Y-shaped connector shown in Fig. 16A;

Fig. 17A is an isometric view of various stages in the fabrication of a distal end assembly for an electrosurgery device that is an embodiment of the invention; and

Fig. 17B is an end view of the complete distal end assembly shown in Fig. 17A.

DETAILED DESCRIPTION; FURTHER OPTIONS AND PREFERENCES

Various aspects of the present inventions are presented below in the context of an electrosurgery system that provides an electrosurgical invasive instrument for use in endoscopic procedures for the removal of polyps and malignant growths through the controlled delivery of both microwave and RF energy. However, it is to be understood that the aspects of the invention presented herein need not be limited to this particular application. They may be equally applicable in embodiments where only RF energy is required, or where only RF energy and fluid delivery is required.

assembly is fixed to the outer cannula tube in a manner that means any rotation applied to the tube is passed to the distal assembly. Accordingly, to permit rotatable manipulation of the distal assembly, a torque transfer unit is mounted on the flexible shaft in order to facilitate rotation thereof.

5 Figs. 4A and 4B show a torque transfer unit 158 ~~that is an embodiment of the invention~~. Essentially the torque transfer unit 158 is an elongate clamp that imparts a gripping force along a length of the flexible shaft. By gripping a length of the shaft, the torque transfer unit can apply a lower maximum pressure, and therefore prevent damage to the flexible shaft and its contents.

10 As shown in Fig. 4A, the torque transfer unit 158 comprises an upper elongate housing member 160 and a lower elongate housing member 162, which are hinged together about a pivot rod 164 at a distal end thereof. The upper elongate housing member 160 and the lower elongate housing member 162 each carry a u-shaped clamping member therein 166. The clamping members 166 oppose one another, whereby pivoting the upper elongate
15 housing member 160 and the lower elongate housing member 162 relative to each other alters the distance between the clamping members 166. A deformable tube 168 is mounted between the clamping members 166. The deformable tube 168 is threaded on to the flexible shaft, which passes through holes 170 in the distal and proximal faces of the torque transfer unit 158. In use, the upper elongate housing member 160 and the lower elongate housing
20 member 162 are pivotable between a release position in which the torque transfer unit can be slid up and down the flexible shaft, and a clamping position, in which the deformable tube 168 is squashed between the clamping members to impart a gripping force on the flexible shaft. The upper elongate housing member 160 and the lower elongate housing member 162 can be retained in the clamping position by a releasable clip 172. The distal end of the
25 torque transfer unit 158 has a series of circumferential indentations designed to be gripped by the thumb and forefinger of the operator, to facilitate rotation.

Fig. 5 is a perspective view of an interface joint 180 in conjunction with a torque transfer unit 158 that is another embodiment of the invention. The torque transfer unit 158 is

Figs. 16A and 16B show the Y-shaped conduits 250 from which the branched passageway is formed. Each Y-shaped conduit has a main linear channel between a first inlet 252 and an outlet 254, and a second channel at an oblique angle to the main linear channel, the second channel having a second inlet 256 and joining the main linear channel about halfway along its length. Each of the first inlet 252 and the second inlet 256 has a rotary luer lock fitting 258.

Distal assembly configuration

Figs. 8, 9A and 9B show details of a distal assembly 214 comprising an active tip that is an embodiment of the invention. Fig. 8 shows an exploded view of the components that form the distal assembly 214. The distal assembly 214 is mounted at the distal end of the outer cannula tube 216 of the flexible shaft 154 that is discussed above. In order to provide a torque transfer function, the majority of the outer cannula tube 216 is formed of a braided tube, e.g. comprising a braided wire (e.g. stainless steel) wrap mounted between a radially inner polymer layer and a radially outer polymer layer. However, to avoid the braid material from interfering with the deliver of RF and/or microwave frequency EM energy to the distal assembly, a distal portion 218 of the outer cannula tube 216 is made purely of the polymer layers, i.e. without an internal braid.

The distal portion 218 of the outer cannula layer 216 fits on to a corresponding proximal part 220 of a protective hull 222. The protective hull is formed from polyether ether ketone (PEEK) or any other suitable engineering plastic, and is shaped to perform a number of functions, i.e.

- mount the distal assembly on the flexible shaft,
- provide a protective undersurface for the active tip,
- provide a protective housing for the needle, and
- locate the active tip relative to the coaxial cable.

The parts of the structure of the hull 222 that perform these functions are discussed in more detail below with reference to Figs. 14A and 14B.

The distal assembly 214 includes an active tip 224, which is a planar piece of dielectric material (e.g. alumina) having conductive layers (e.g. of gold) on its upper and lower

In practice, it may not be necessary to activate the coagulation function for longer than 10 s due to concerns over perfusion at the tip resulting in potential full wall thickness injury to the bowel wall.

Figs. 11A, 11B and 11C illustrate the dimensions of one example of an active tip 224 that can be used in embodiments of the invention. The overall length of the active tip is 10.6 mm, with a maximum width of 2 mm and a height of 0.5 mm. The layer of metallisation on the active tip has a thickness of 0.03 mm. The curved distal end is manufactured as a plurality of radiused sections of decreasing length and radius towards the distal tip. In this embodiment example, there are five different radiused section, but more could be used. The length of each section and its corresponding radius of curvature is given in Table 1:

Section length (mm)	Radius of curvature (mm)
1.6	12.4
1.0	10.2
0.7	3.2
0.2	0.85
0.1	0.35

Table 1: Curvature at distal end of active tip

As mentioned above, the conductive layers on both surface are set back from the edges of the dielectric substrate by a distance of 0.2 mm along the proximal 6 mm of the tip. And to ensure that the top conductive layer is isolated from the outer conductor of the coaxial cable, the top conductive layer is set back from the proximal edge of the dielectric substrate by a distance of 0.6 mm.

Figs. 12A and 12B depict the transition from the push rod 130 to the needle 234. A needle ferrule 240 is connected to the push rod 130 at a proximal end thereof and is connected to the needle 234 at a distal end thereof. A set of holes in the outer surface of the needle ferrule 240 permits ingress of fluid from the flexible shaft for delivery out of the needle

234. As shown in Fig. 12B, the push rod 130 acts as a stopper in the proximal end of the ferrule 240, thereby preventing fluid from escaping in the wrong direction.

Fig. 13 illustrates schematically the flow path for the fluid. Immediately proximal of the distal assembly the injected fluid that has passed down the flexible shaft 154 from the syringe is forced through four small radial holes 242 central to the needle ferrule 240 and thence into the hypodermic needle 234 for injection into the patient.

Figs. 14A and 14B show the shape of the protective hull 222. As shown more clearly in Fig. 9B, the distal end of the hull is shaped to permit the active tip to overhang it by around 0.2 mm around the distal edge except at the distal tip. The surface that contacts the underside of the active tip therefore has a maximum width of 2 mm, which narrows to 1.6 mm in an intermediate portion 223 before tapering to its distal tip in a distal portion 225. The distal tip may be a single radiused curve, e.g. having a radius of 0.2 mm.

Meanwhile the proximal end of the hull defines an oblong recess for receiving the proximal end of the active tip. The oblong recess is bordered by a pair of wings 244 on each side, which act to retain and align the active tip as well as define a volume for receiving the adhesive that covers the exposed inner conductor of the coaxial cable.

Fig. 17A shows various stages in the assembly of a distal end portion 300 for an electrosurgical instrument that is another embodiment of the invention. The leftmost view in Fig. 17A shows an inner tube 302 made of a conductive material. This inner tube 302 represents the inner conductor of the coaxial feed discussed above. The second view from left in Fig. 17A shows an outer tube 304, which first over the inner tube 302. The outer tube 304 may be formed as a tube of insulating dielectric material having a conductive coating on its outer surface. The conductive coating acts as the outer conductor of the coaxial feed.

At the distal end of the outer tube, a portion of the conductive coating is etched away to expose a portion 306 of dielectric material. An island 308 of conductive coating is left on the top surface of the outer tube at its distal end. The island 308 is separated (i.e. electrically isolated) from the rest of the conductive coating 304 by the exposed portion