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(54) **SURGICAL ACCESS APPARATUS AND METHOD**

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(57) **ABSTRACT**

A surgical access device includes a single valve that forms a seal with the body wall and provides an access channel into a body cavity. The valve has properties for creating a zero seal in the absence of an instrument as well as an instrument seal with instruments having a full range of instrument diameter. The valve can include a gel and preferably an ultragel comprised of an elastomer and an oil providing elongation greater than 1000 percent and durometer less than 5 Shore A. The shore valve can be used as a hand port where the instrument comprises the arm of a surgeon, thereby providing hand access into the cavity.

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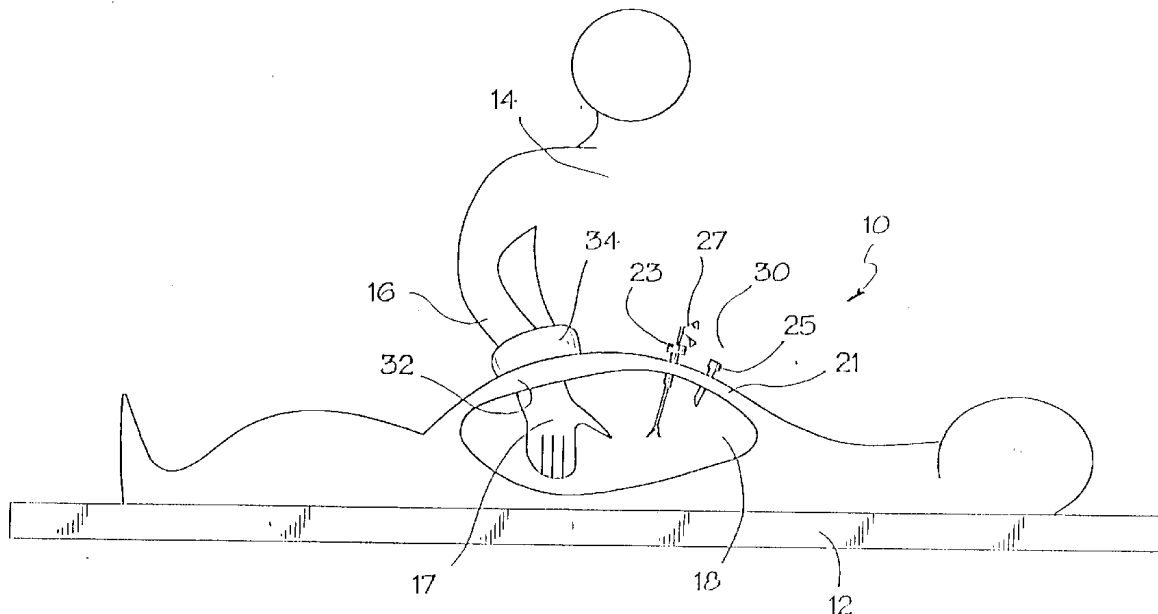
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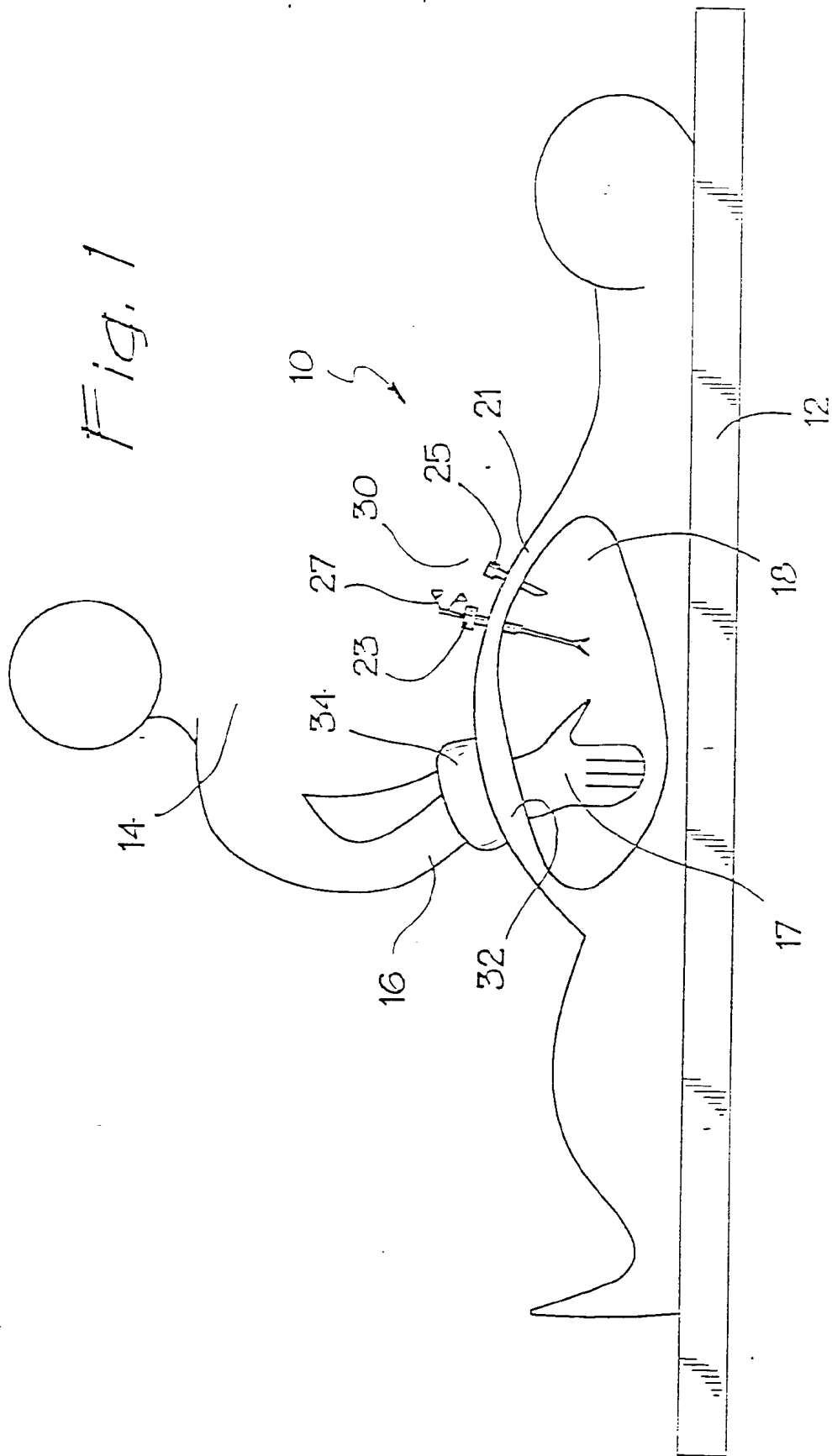
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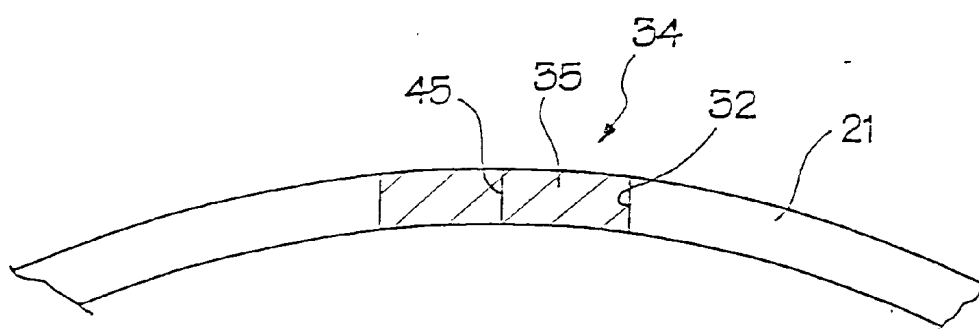
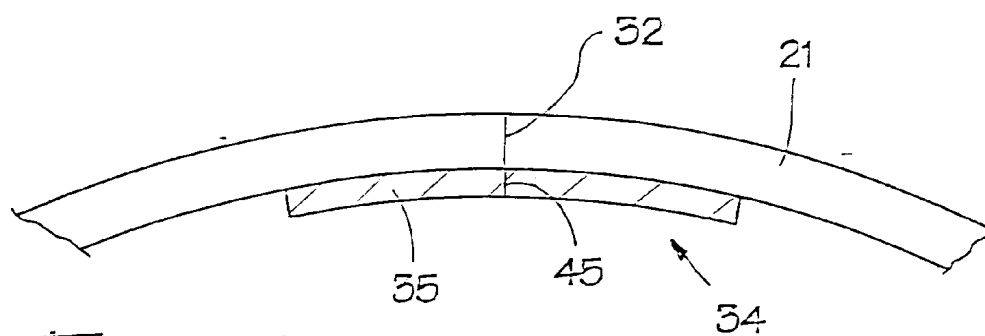
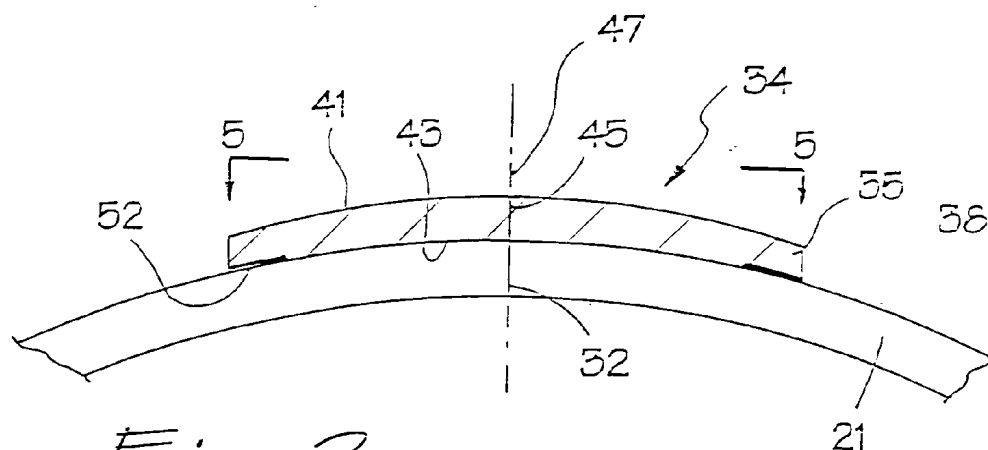
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A method for making the surgical access device includes the combining or a gelling agent with an oil, preferably in a molding process. A method for using the device includes steps for creating an opening with the instrument. In a particular process, an organ can be removed from the body cavity through the single valve to create an organ seal while the organ is addressed externally of the body cavity. The valve and method are particularly adapted for laparoscopic surgery wherein the abdominal cavity is insufflated with a gas thereby requiring the zero seal, the instrument seal, and the organ seal in various procedures.







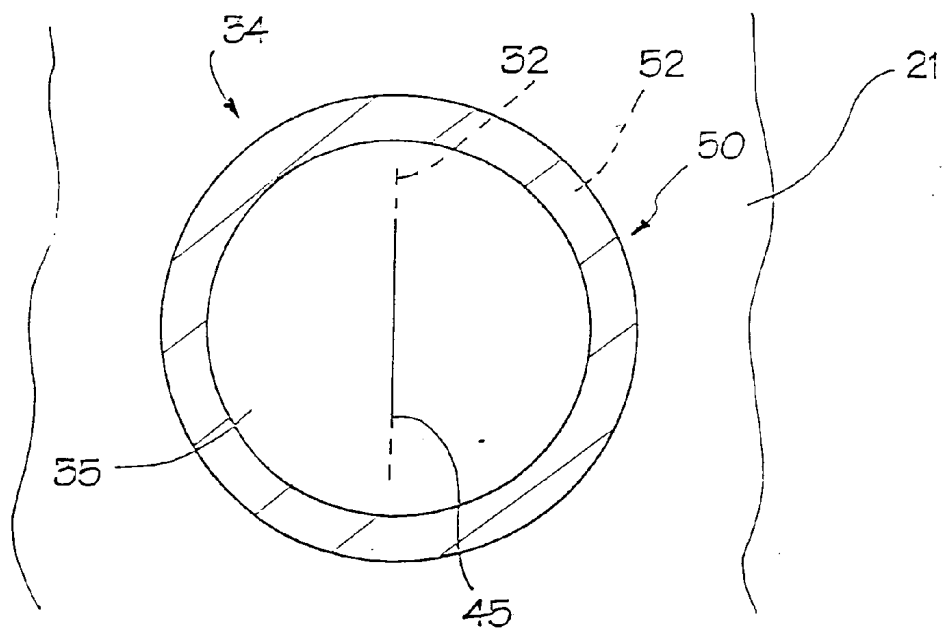


Fig. 5

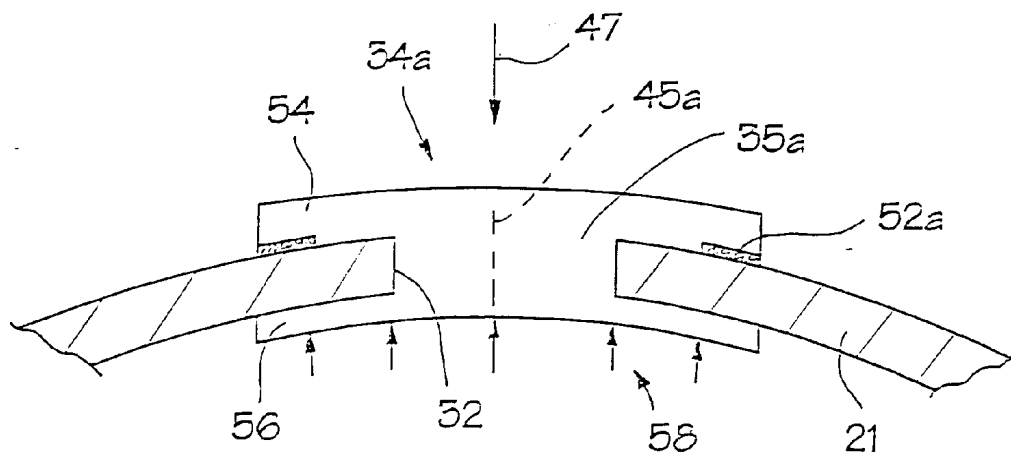


Fig. 6

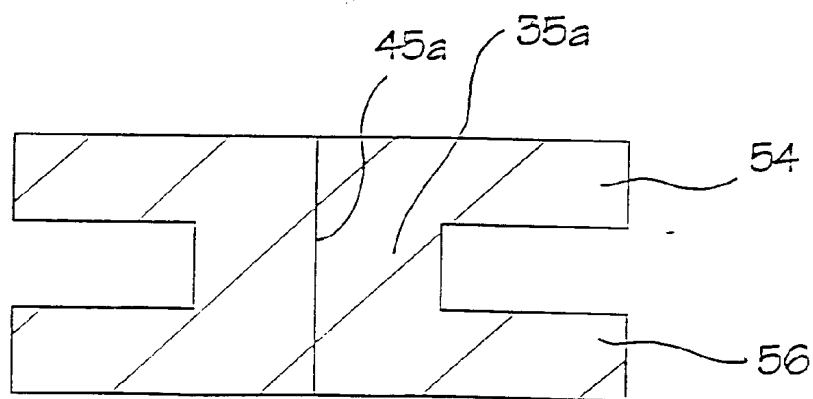
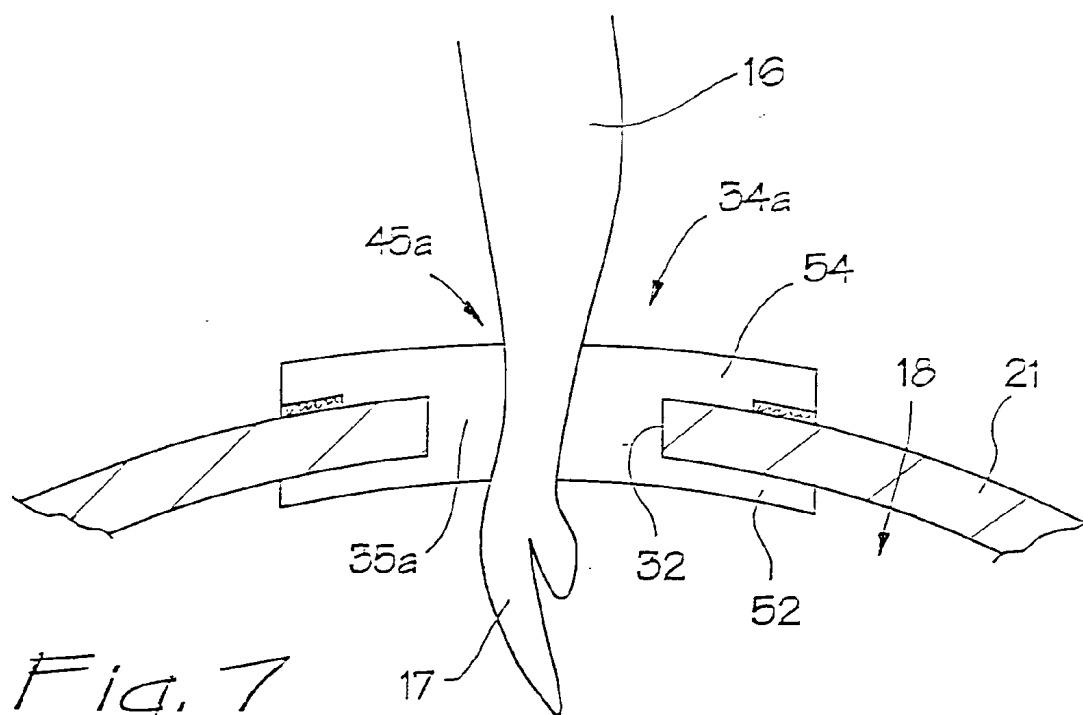


Fig. 8

Fig. 9

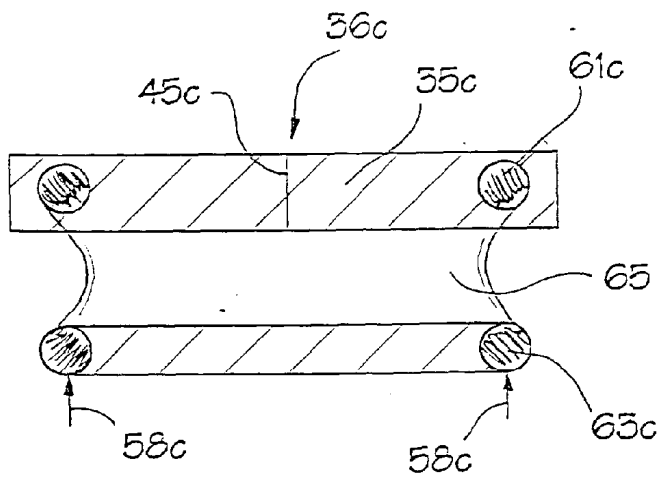
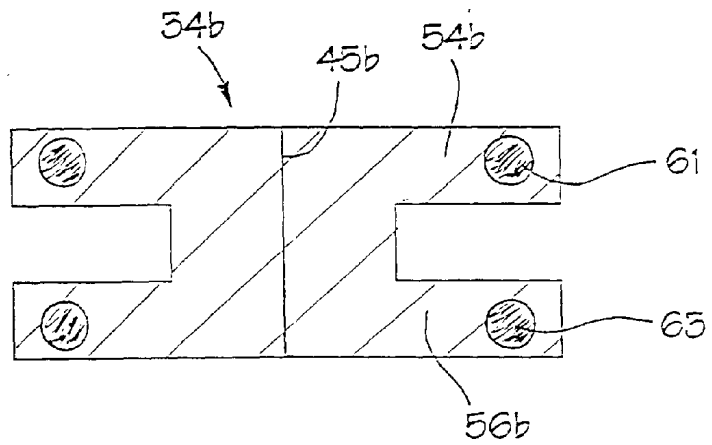
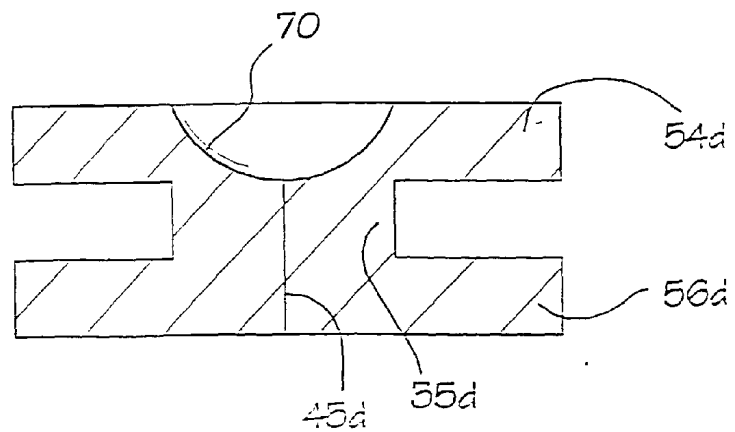


Fig. 10

Fig. 11



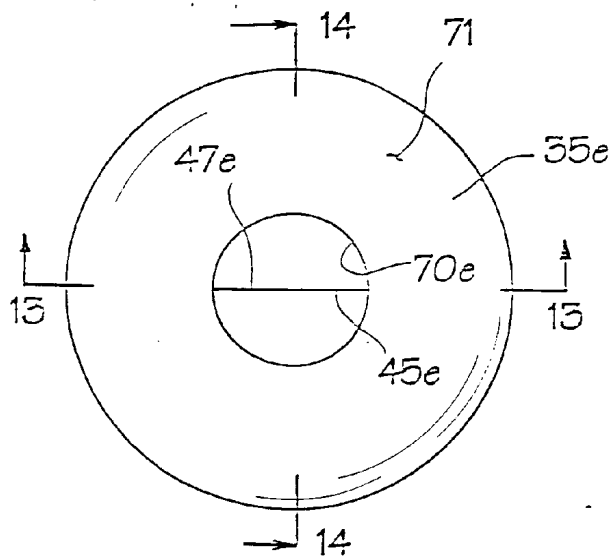


Fig. 12

Fig. 13

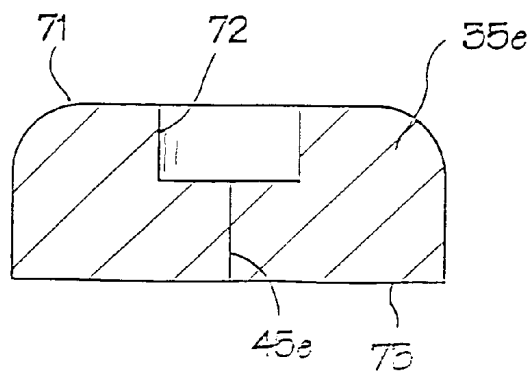
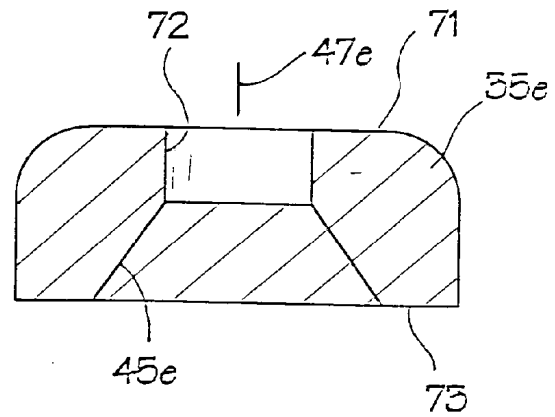


Fig. 14

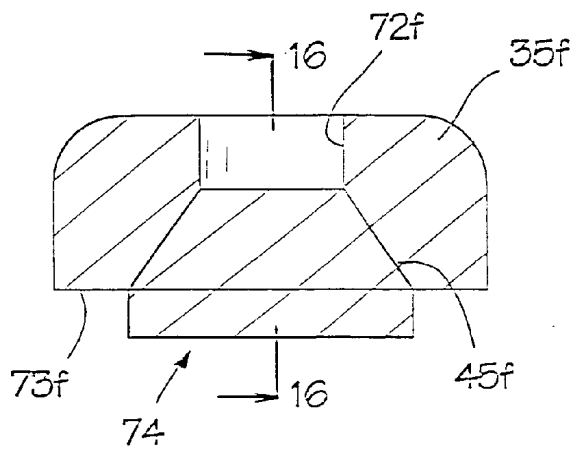


Fig. 15

Fig. 16

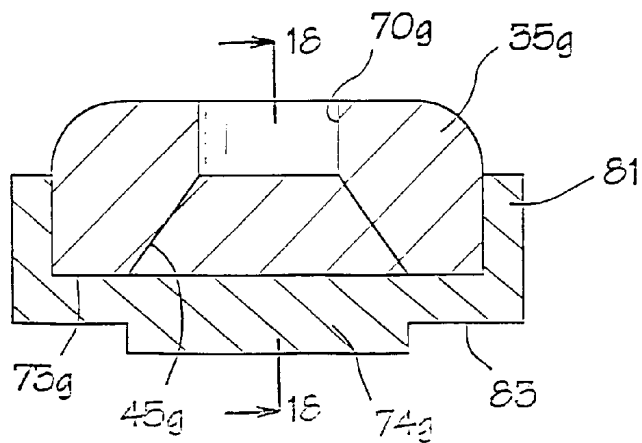
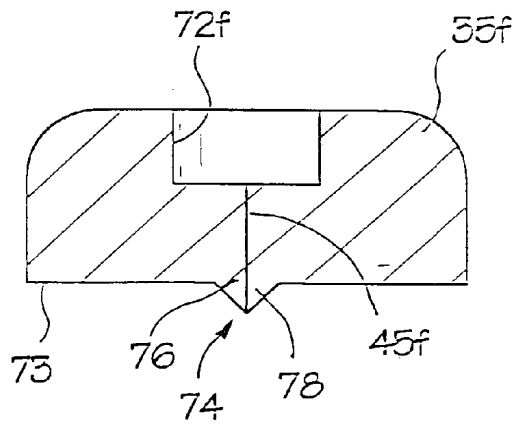


Fig. 17

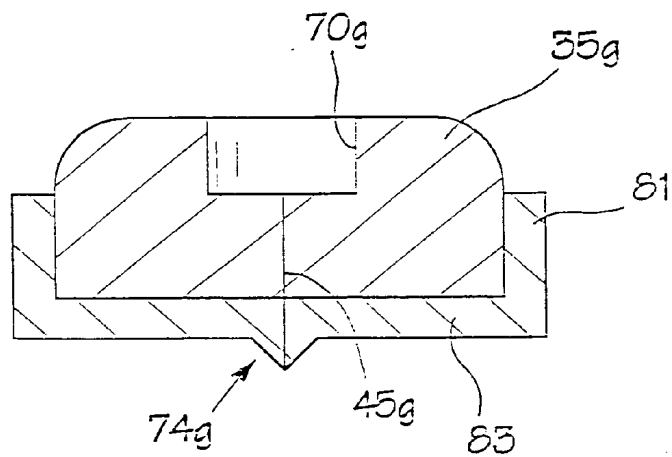


Fig. 18

Fig. 19

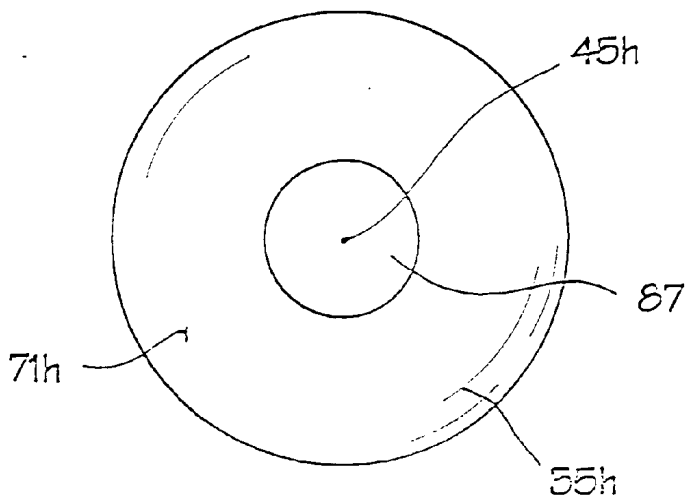
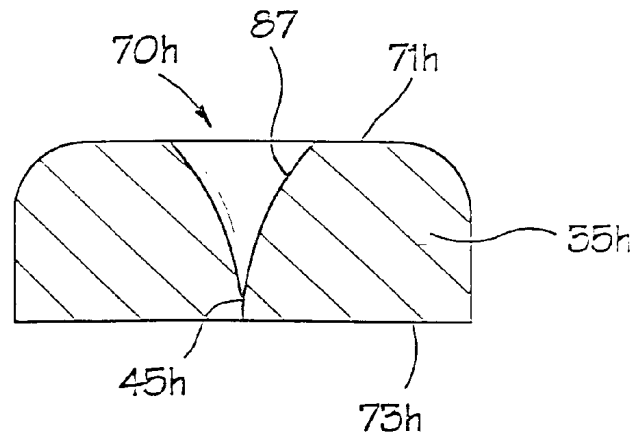
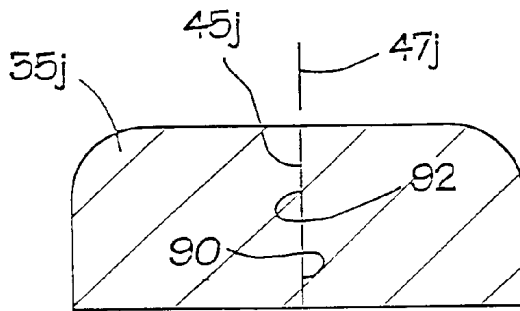
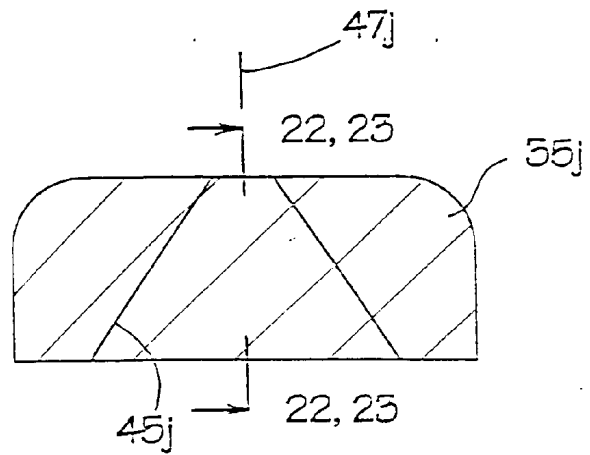


Fig. 20

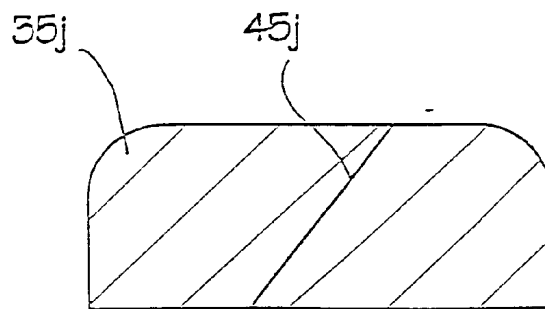
Fig. 21



73j

Fig. 22

Fig. 23



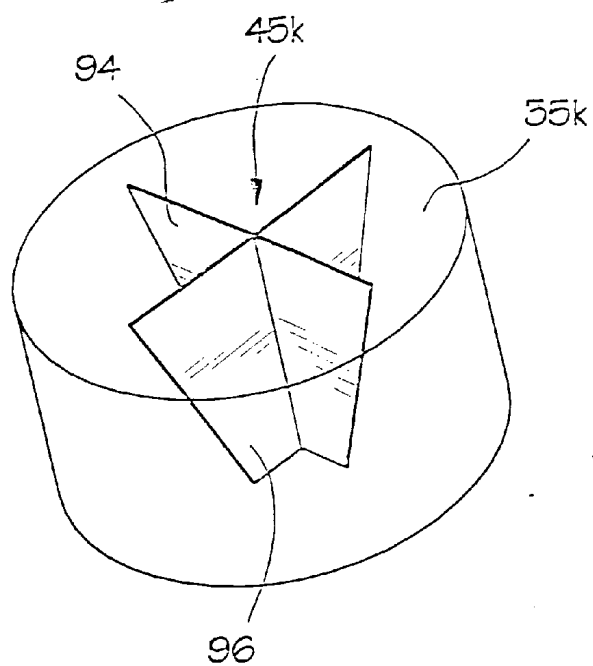


Fig. 24

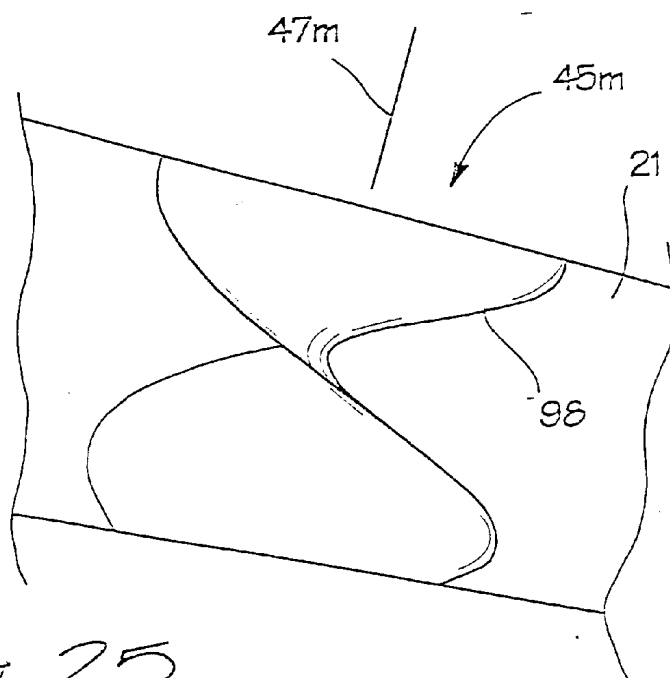


Fig. 25

Fig. 26

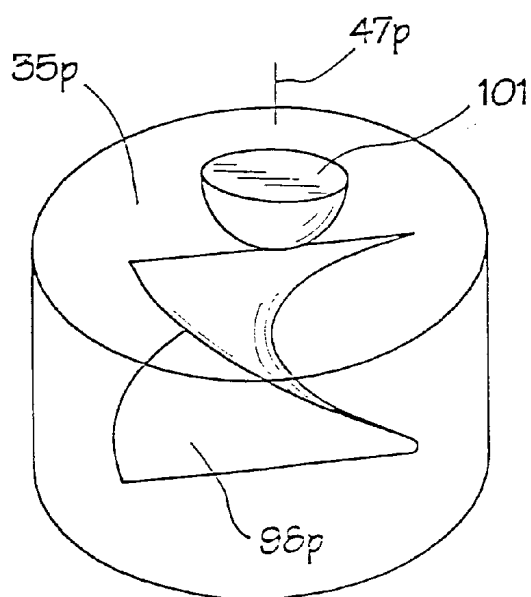
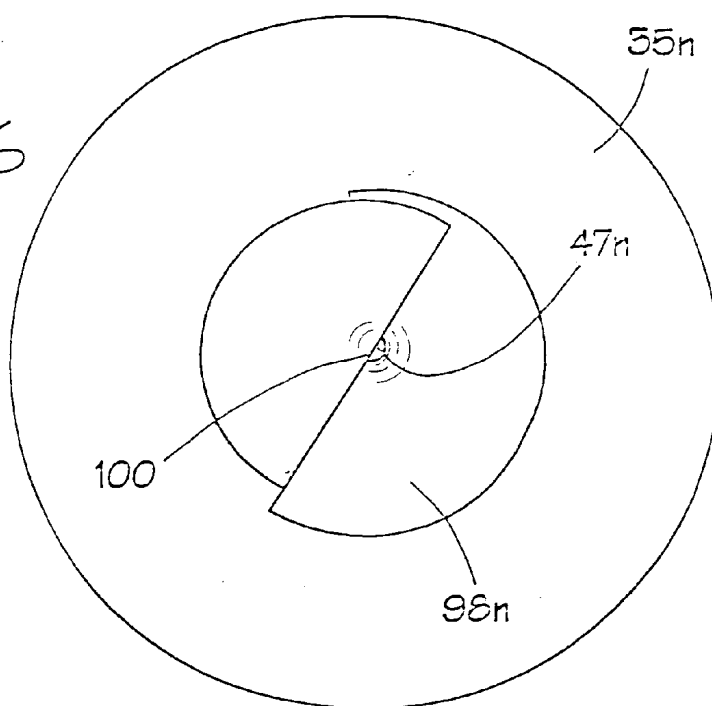


Fig. 27

Fig. 28

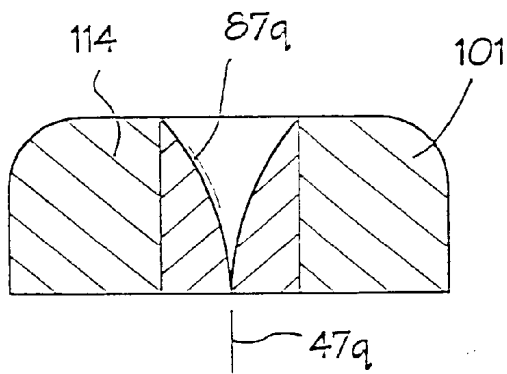
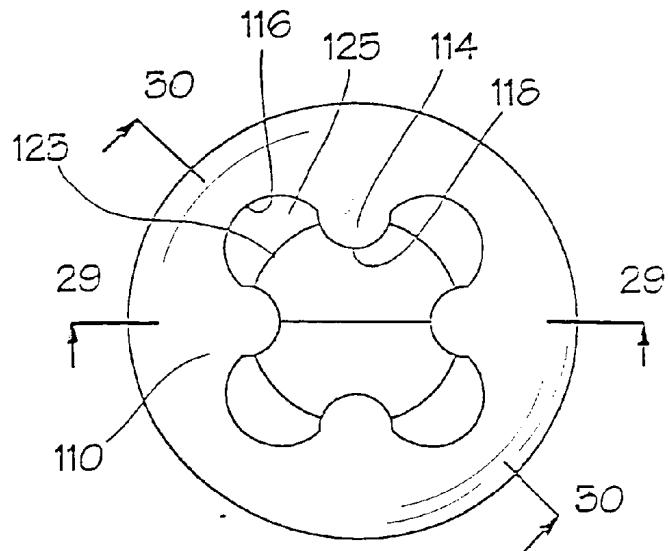


Fig. 29

Fig. 30

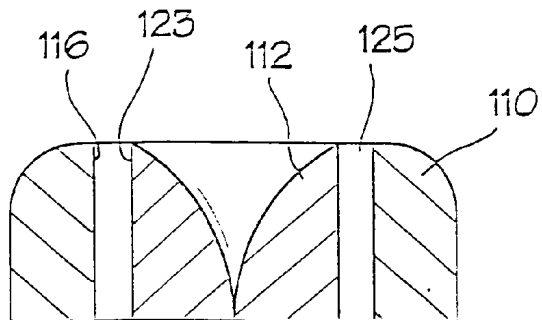


Fig. 31

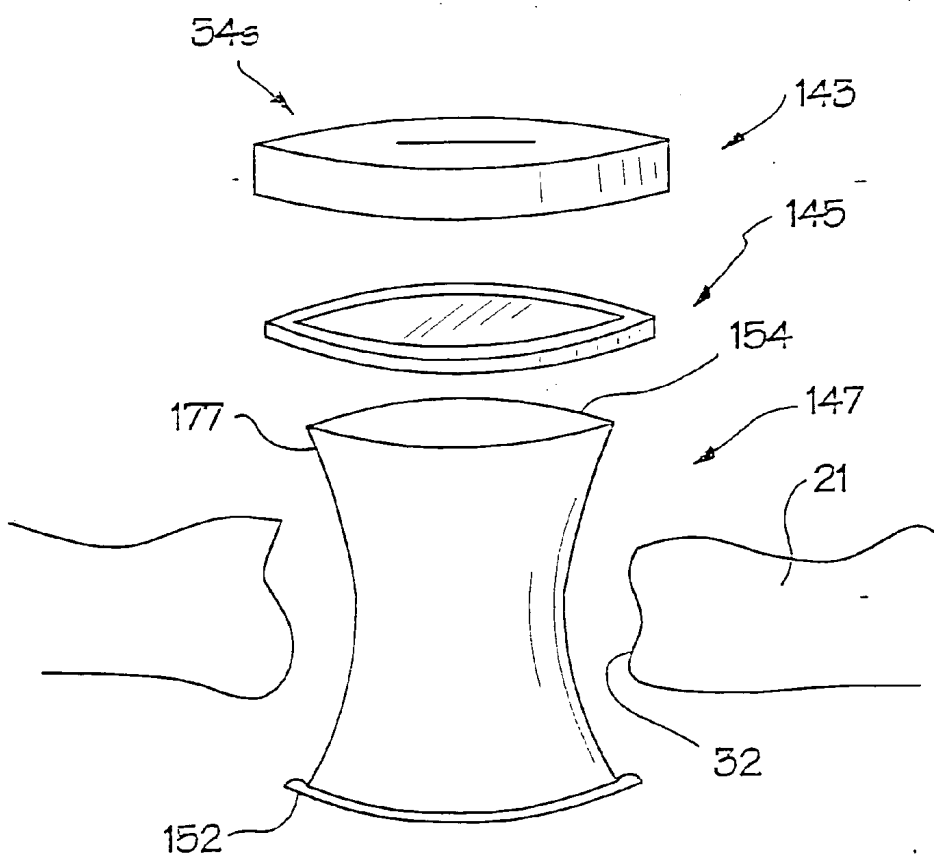
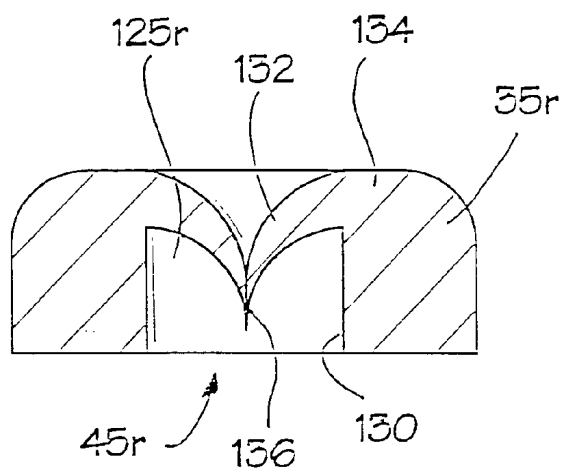


Fig. 32

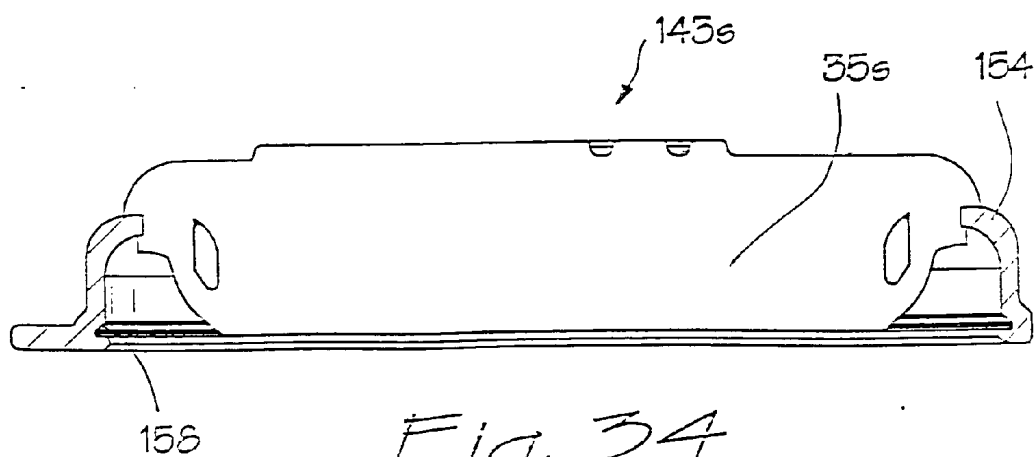
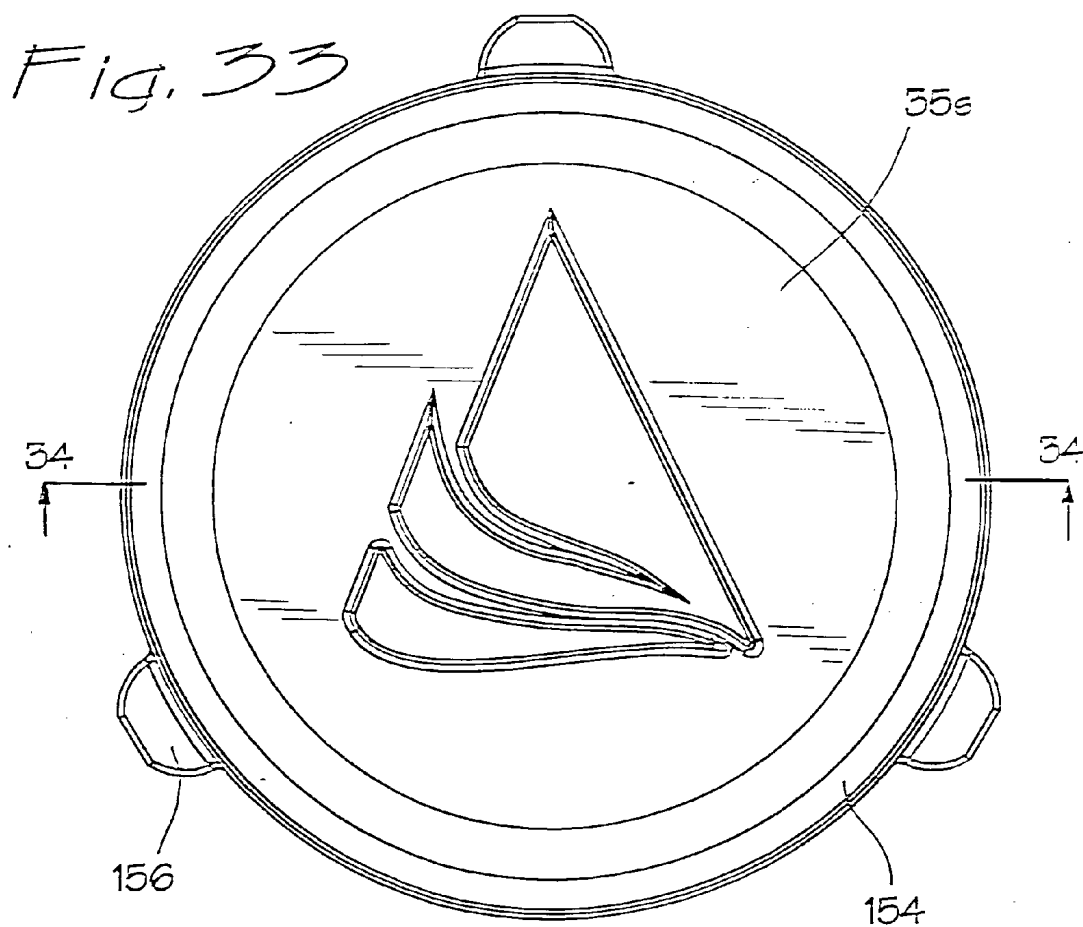


Fig. 35

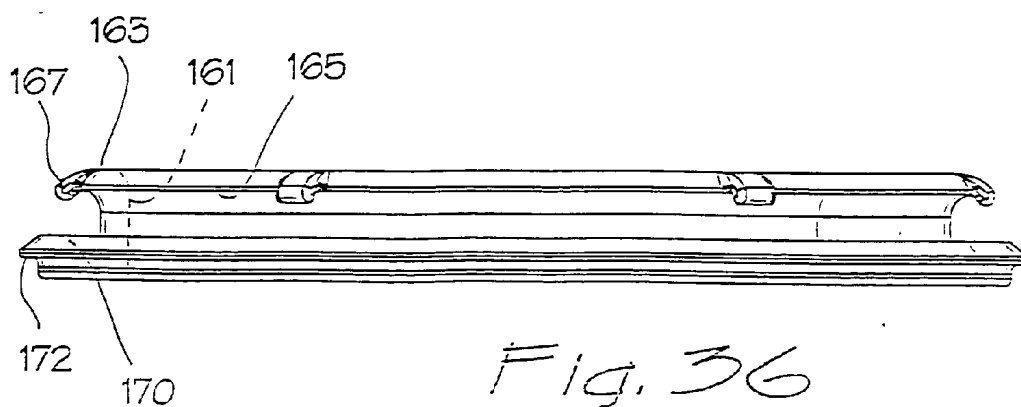
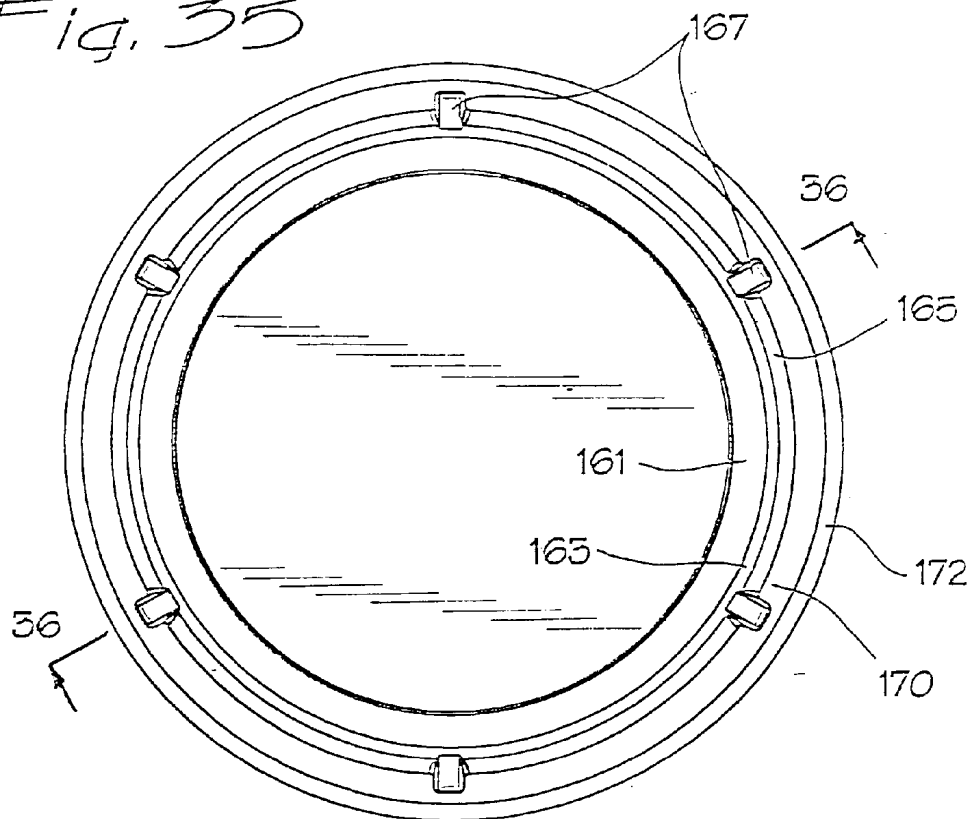
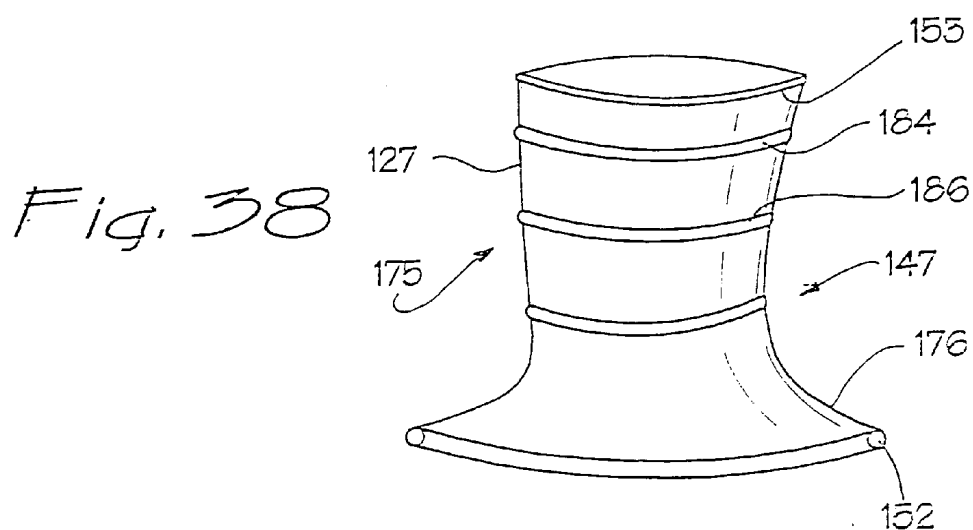
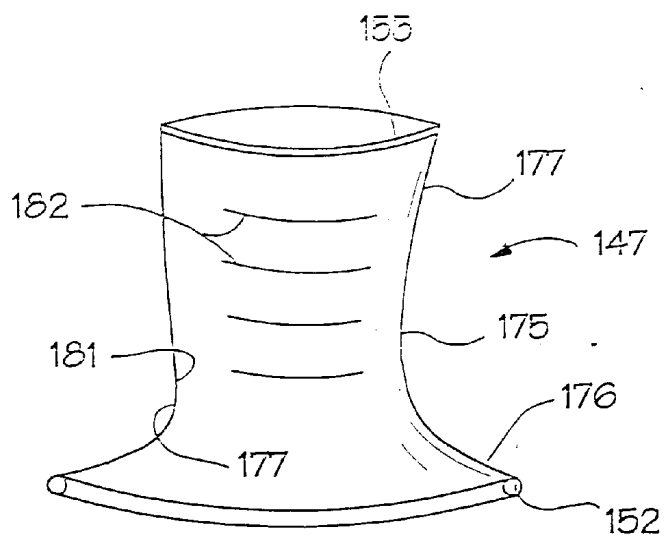


Fig. 36



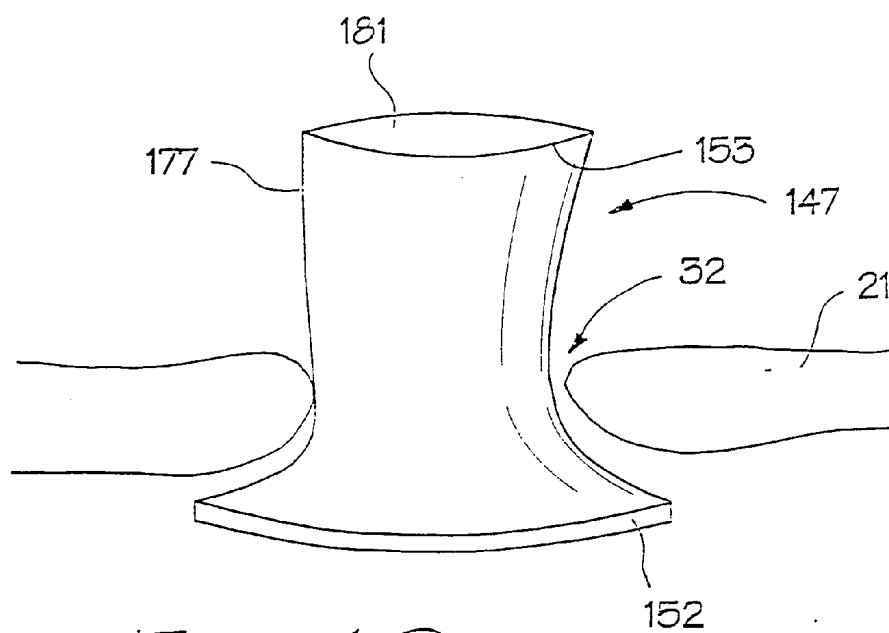
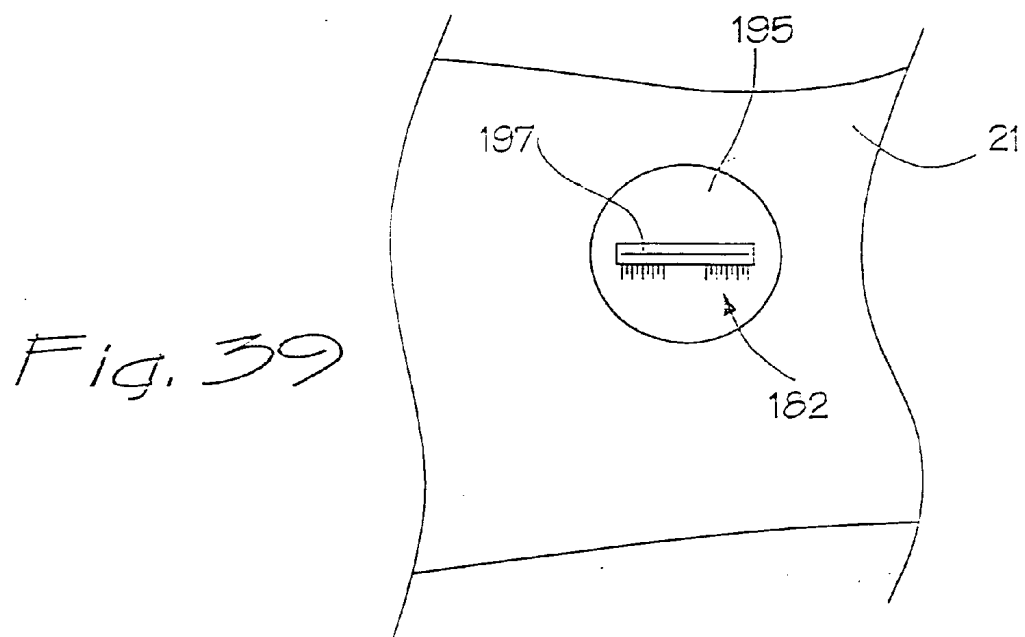


Fig. 40

Fig. 41

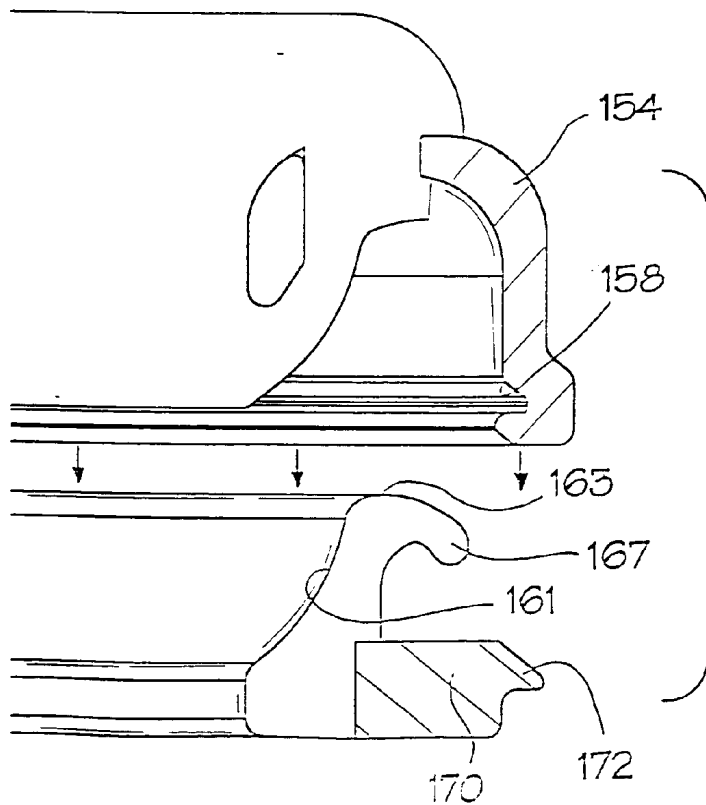
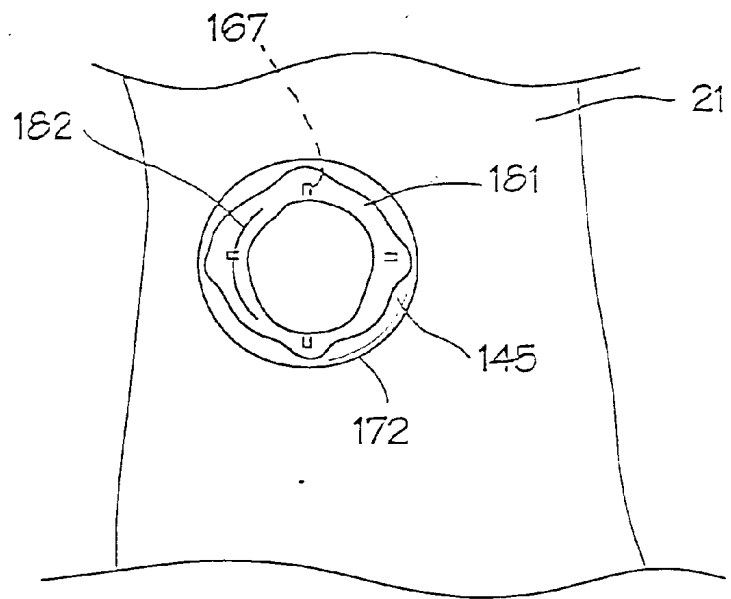


Fig. 42

SURGICAL ACCESS APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates generally to devices and other apparatus facilitating sealed access with surgical instruments such as guidewires, endoscopes, and even the hand of a surgeon into a body cavity.

[0003] 2. Background of the Invention

[0004] In several areas of surgery there exists a need to have mechanisms or devices that can seal a body cavity or space, and yet permit the introduction of surgical instruments such as guidewires, endoscopes, and even the hand of a surgeon. Typical of these areas of surgery is laparoscopic surgery which relies on surgical instruments inserted through the abdominal wall to reach an operative site within the abdominal cavity. In order to increase space around the operative site within the cavity, insufflation gases are typically introduced to inflate the cavity and elevate the abdominal wall. This pressurizing of the abdominal cavity is referred to as pneumoperitoneum. In this context, the need to seal the body cavity or space arises from the need to maintain the pneumoperitoneum even when instruments are present.

[0005] Trocars have been commonly used to provide instrument access in laparoscopic surgeries. These trocars have included elaborate seal structures having zero seals which prevent escape of the gases in the absence of instruments, and instrument seals which prevent escape of the gases in the presence of instruments. Unfortunately, the instrument seals have been able to accommodate only a narrow range of instrument diameters. Where wider ranges were desired multiple seal pairs had to be provided.

[0006] Some instruments, such as the hand of the surgeon, have been too large for trocar access. Under these circumstances, hand-assisted laparoscopic seals have been provided. Such devices have been large, cumbersome, and largely ineffective in providing the required sealing mechanism. Other access devices, such as Touhy-Borst seals, have been used but only for very small diameter access such as that required by a guidewire.

[0007] Each of the prior devices suffers from drawbacks which make the device difficult or cumbersome to use. For example, a Touhy-Borst seal requires two hands to use and does not form a seal when a guidewire or other device is about to be introduced. Present trocar seals and hand-assisted seals require two valves, one forming an instrument seal in the presence of the instrument, and the other forming a zero seal in the absence of the instrument. For example, in hand-assisted devices, elaborate mechanisms have been required to seal around the surgeon's arm. When the arm is removed, a separate zero seal has been required to prevent the escape of blood or insufflation gases.

SUMMARY OF THE INVENTION

[0008] These deficiencies of the prior art are overcome with the present invention which includes both a seal apparatus and a method for using this apparatus to perform elaborate surgeries. In one embodiment, the device includes a valve structure formed of a gel including, for example, a

thermoelastic base such as KRATON (a trademark of Shell Corporation) and an oil. The resulting elastomer has an excellent tear strength, elongation greater than 1,000 percent, a very low durometer or hardness, and biocompatibility. A process for manufacturing this device is greatly simplified using molding techniques.

[0009] Importantly, the access device can function as both a zero seal and an instrument seal. Furthermore, it can accommodate a full range of instrument diameters, such as a range from two French in the case of a guidewire, to three or four inches in the case of a surgeon's hand. In addition, several instruments can be accommodated at the same time with a single access device.

[0010] Both tear resistance and sealing capability can be enhanced by encapsulating the gel in a sheath or otherwise providing circumferential reinforcement for the valve structure. Additives can be provided either on or in the gel to enhance properties such as lubricity, appearance, wound treatment and/or protection, anti-cancer protection and antimicrobial protection. Additional chemicals, compounds, pharmaceuticals or even mechanical devices can be mixed with or embedded in the gel material to vary chemical, pharmaceutical or physical properties of the access device.

[0011] These and other features and advantages of the invention will be clarified with a description of preferred embodiments and reference to the associated drawings.

DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a perspective view showing a patient prone on an operating table with his abdomen insufflated, and with instrument access provided by trocars and the access device of the present invention;

[0013] FIG. 2 is an enlarged side elevation view of the access device of FIG. 1 operatively disposed exteriorly as the abdominal wall;

[0014] FIG. 3 is a side elevation view similar to FIG. 2 showing the access device operatively disposed interiorly of the abdominal wall;

[0015] FIG. 4 is a side elevation view similar to FIG. 2 showing the access device operatively disposed within an incision in the abdominal wall;

[0016] FIG. 5 is a plan view taken along lines 5-5 of FIG. 2;

[0017] FIG. 6 is a side elevation view similar to FIG. 2 and illustrating a further embodiment of the access device having an external flange and an internal flange;

[0018] FIG. 7 is a side elevation view similar to FIG. 6 and illustrating the hand of a surgeon being inserted through the access device;

[0019] FIG. 8 is an axially cross section view of the access device illustrated in FIG. 6;

[0020] FIG. 9 is a cross section view similar to FIG. 8 and illustrating an embodiment with circumferential reinforcement members;

[0021] FIG. 10 is an axial cross section view similar to FIG. 9 and illustrating a double-ring retractor with an access device of the present invention;

[0022] FIG. 11 is a radial cross section view similar to FIG. 8 and illustrating an embodiment having a lead-in cavity or pocket;

[0023] FIG. 12 is a top plan view of the embodiment illustrated in FIG. 11;

[0024] FIG. 13 is an axial cross section view taken along lines 13-13 of FIG. 12;

[0025] FIG. 14 is an axial cross section view taken along lines 14-14 of FIG. 12;

[0026] FIG. 15 is an axial cross section view similar to FIG. 13 and illustrating an embodiment with a duct-bill valve;

[0027] FIG. 16 is an axial cross-section view taken along lines 16-16 of FIG. 15;

[0028] FIG. 17 is a radial cross section view similar to FIG. 13 comprising a softer hand seal and a firmer base seal;

[0029] FIG. 18 is an axial cross section view taken along lines 18-18 of FIG. 17;

[0030] FIG. 19 is an axial cross section view of an embodiment having a lead-in cavity or pocket with a conical or funnel configuration;

[0031] FIG. 20 is a top plan view of the embodiment illustrated in FIG. 19;

[0032] FIG. 21 is an axial cross section view similar to FIG. 13 and showing another embodiment with a trapezoidal slit;

[0033] FIG. 22 is an axial cross section view taken along lines 22-22 of FIG. 21;

[0034] FIG. 23 is an axial cross section view similar to FIG. 22 taken along lines 23-23 of FIG. 21 and illustrating a slit having other than a perpendicular relationship to the plane of the pad;

[0035] FIG. 24 is a perspective view of a further embodiment of the access device having: an opening formed by multiple slits angularly disposed and axially spaced relative to each other;

[0036] FIG. 25 is a side elevation view of an access device with a slit having a spiral configuration;

[0037] FIG. 26 is a top plan view of an access device having a spiral slit and axial channel;

[0038] FIG. 27 is a side elevation view of an embodiment having a spiral slit and a septum seal;

[0039] FIG. 28 is an axial cross section view of a further embodiment including a superelastic conical seal and a flexible base with annular spoke-like cams;

[0040] FIG. 29 is an axial cross section view taken along lines 29-29 of FIG. 22;

[0041] FIG. 30 is an axial cross section view taken along lines 30-30 of FIG. 22;

[0042] FIG. 31 is an axial cross section view similar to FIG. 28 and illustrating an embodiment including flappers;

[0043] FIG. 32 is a perspective exploded view of a further embodiment including a gel cap, a base, and a retraction sheath;

[0044] FIG. 33 is a top plan view of the gel cap of FIG. 32;

[0045] FIG. 34 is an axial cross section view taken along lines 34-34 of FIG. 33;

[0046] FIG. 35 is a top plan view of the base illustrated in FIG. 32;

[0047] FIG. 36 is an axial cross section view taken along lines 36-36 of FIG. 35A;

[0048] FIG. 37 is a side elevation view of the retraction sheath illustrated in FIG. 32;

[0049] FIG. 38 is a side elevation view of a further embodiment of the retraction sheath;

[0050] FIGS. 39-42 illustrate progressive steps in a preferred method of use associated with the embodiment of FIG. 32;

[0051] FIG. 39 is a top plan view showing use of a template;

[0052] FIG. 40 is a top plan view of showing placement of the retraction sheath;

[0053] FIG. 41 is a top plan view showing placement of the base ring and securement of the traction sheath; and

[0054] FIG. 42 is an axial cross section view partially in section showing placement of the gel cap relative to the base.

DESCRIPTION OF PREFERRED EMBODIMENTS AND BEST MODE OF THE INVENTION

[0055] A patient is illustrated in FIG. 1 and designated generally by the reference numeral 10. The patient 10 is shown in a prone position on an operating table 12, where abdominal surgery is being performed by a surgeon 14 having an arm 16 and a hand 17. In the illustrated example, the operative procedure is performed within an abdominal cavity 18 with instrument access provided through an abdominal wall 21. In this type of operation, commonly referred to as laparoscopic surgery, trocars 23 and 25 are commonly used to provide minimally invasive access through the abdominal wall 21 for instruments such as a grasper 27 and an endoscope 30.

[0056] Although the specific focus of this disclosure will be on a preferred laparoscopic procedure, it will be noted that laparoscopic surgery is merely representative of a type of operation wherein a procedure can be performed in a body cavity with minimal access through a body wall.

[0057] Notwithstanding the foregoing generality, it is important to note that with respect to laparoscopic surgery, it is often desirable that the surgeon 14 be able to insert his/her hand 17 through the abdominal wall 21 and into the abdominal cavity 18. This insertion of the hand 17 provides the surgeon 14 with direct access to various elements of the anatomy.

[0058] In order to accommodate the hand 17 and arm 14, of the surgeon 14, a small incision 32 is typically created in the abdominal wall 21. An access device 34 of the present invention can be provided to further facilitate this access by the hand of the surgeon 14.

[0059] Particularly in the case of laparoscopic surgery, it is advantageous to insufflate the abdominal cavity 18 with a gas, such as carbon dioxide, in order to elevate the abdominal wall 21 and thereby increase the volume of the working space within the cavity 18. Maintenance of this insufflation pressure, commonly referred to as pneumoperitoneum, is particularly difficult where access is desired across the abdominal wall 21, for example, through the trocars 23, 25, as well as the access device 3'. For this reason, a substantial effort has been directed to providing such access devices with sealing characteristics both in the presence of instruments and in the absence of instruments, such as the grasper 29, scope 30 and hand 27.

[0060] Thus, the trocars 23 and 25 have typically been provided with complex valve structures, including, for each narrow range of instrument sizes, an instrument valve which forms an instrument seal in the presence of an instrument, and a zero valve which forms a zero seal in the absence of an instrument. By providing both an instrument seal and a zero seal the valve structures have been able to inhibit the escape of gases through the trocars both in the presence and the absence of an instrument, respectively.

[0061] The instrument seals have been particularly cumbersome, as noted, and have only been effective for a small range of instrument diameters. For example, separate instrument seals have been needed for instruments, such as guidewires, which may have a diameter of only two French to three French. For medium-sized instruments having diameters of three millimeter to five millimeters, a second instrument seal has been required. In some cases, even a third instrument seal has been necessary in order to accommodate instruments having diameters such as nine millimeters to 12 millimeters. Typically the varying sizes of instruments have also required individual zero seals for each range. Thus, in a complex trocar, such as the trocar 23, there might be as many as six separate seals associated with the access device.

[0062] Were it not for the desire to maintain the pneumoperitoneum, there would be no need for the trocars 23, 25 or the access device 34. One would merely cut an incision in the abdominal wall 21 and insert the instrument directly through the incision. However, without appropriate valves or seals, the insufflation gases would merely escape through the incisions. This would be particularly detrimental in the case of the incision 32 which must be sufficiently large to accept the hand 17 of the surgeon 14. Thus it is a primary purpose of the access device 34 to form with the incision 32 an access or working channel 34, and to provide a valve or other sealing structure across the working channel 34 in order to maintain the pneumoperitoneum.

[0063] An enlarged view of one embodiment of the access device 34 is illustrated in FIG. 2 which also shows the abdominal wall 21 and the incision 32. In this simple form, the access device 34 has the general configuration of a pad 35, meaning that it is generally flat and disposed in a plane such as the plane 38. Typically parallel to this plane 38 are a pair of major surfaces of 41 and 43 which provide the pad 35 with a substantial surface area. An opening or slit 45 can be formed through the pad 35, generally along an axis 47 perpendicular to the plane 38.

[0064] When operatively disposed, the opening 45 of the pad 35 is in communication with the incision 32 and, in this case, forms with the incision 32, the working channel 36.

The alignment of the opening 45 and incision 32 can occur with the pad 35 disposed exteriorly of the abdominal wall as illustrated in FIG. 2, interiorly of the abdominal wall is 21 as illustrated in FIG. 3, or within the abdominal wall 21 as illustrated in FIG. 4. In any of these positions, operative disposition of the pad 35 relative to the abdominal wall 21 requires that the pad 35 be maintained in its operative position and that it form a seal around the incision 32. Referring to the plan view of FIG. 5, these two functions are accomplished with an adhesive 50 disposed around the incision 32 between the pad 35 and the abdominal wall 21.

[0065] If this adhesive 50 is formed as a continuous ring 52, as illustrated in FIG. 5, the pad 35 can be disposed with the ring 52 positioned circumferentially around the incision 32 to form a seal between the pad 35 and the abdominal wall 21. In the illustrated example, when the pad 35 is operatively positioned, the escape of insufflation gases is inhibited between the pad 35 and the abdominal wall 21 by the adhesive ring 52.

[0066] The escape of insufflation gases is inhibited through the opening 45 of the pad 35 by the self-sealing characteristics of the material forming the pad 35. This material and its highly advantageous properties are discussed in significant detail below.

[0067] It will be appreciated that the functions of the adhesive ring 52 can be accomplished in many different ways using many different materials and shapes. For example, many materials other than adhesives can be used to maintain the pad 35 in position over the incision 32. The formation of a seal around the incision 32 can also be accomplished with methods other than adhesion. Furthermore, the shape of the continuous seal formed by the adhesive 50 need not be in the shape of a circle. Rather, any continuous pattern sufficiently large to form a perimeter around the incision 32 could facilitate the desired sealing relationship. Finally, it will be noted that the mere placement of the pad 35, for example, interiorly of the abdominal wall 21 as illustrated in FIG. 3, may produce a perimeter seal merely as a result of the insufflation pressure.

[0068] A further embodiment of the access device 32 is illustrated in FIG. 6 where elements of structure similar to those previously disclosed or designated with the same reference numeral followed by the lower case "a." In this embodiment, the functions of position-maintenance and sealing are accomplished with an alternative configuration for the access device itself. The pad 35 in this case is disposed within the incision 32 as illustrated in FIG. 4. However, an external flange 54' and an internal flange 56 are formed integral with the pad 35.

[0069] When operatively disposed, the external flange 54 is positioned outside of the abdominal wall 21 while the internal flange 56 is disposed interiorly of the abdominal wall 21a. In this matter, the pad 35 can be disposed within the incision 32a and held in position by the flanges 54, 56. When the hand 17 of the surgeon 14 is inserted through the access device 34, the exterior flange 54 prevents the pad 35a from moving distally. Similarly, when the hand 17 of the surgeon 14 is withdrawn, the interior flange 56 prevents the pad 35a from moving proximally.

[0070] In this embodiment, the opening 45a extends through the pad 35a as well as the flanges 54 and 56, and completely defines the working channel 34 through the incision 32.

[0071] The primary seal which is required between the access device **34a** and the abdominal wall **21**, can be formed with the adhesive ring **52a** as discussed with reference to **FIG. 6**. Alternatively, this embodiment including the interior flange **56** may rely merely upon the surface contact between the flange **56a** and the abdominal wall **21**. In this case, the primary seal can be formed between these structural elements and enhanced by the pneumoperitoneum pressure which forces the interior flange **56** against the abdominal wall as illustrated by a plurality of arrows **58**. This seal is formed primarily in a radial plan generally perpendicular to the axis **47**.

[0072] The function of the primary seal may be further enhanced by additional sealing which occurs between the pad **35a** and the portions of the abdominal wall **21** forming the incision **32**. In this location, the abdominal wall **21** is radially compressed by the mere presence of the pad **35** within the incision **32**. The resulting pressure produces an axial seal between the pad **35a** and the abdominal wall **21**.

[0073] If the adhesive ring **52a** is desired for this embodiment, it is most advantageously placed around the incision **32**, between the exterior flange **54** and the abdominal wall **21**.

[0074] It will be noted that whenever an instrument, such as the arm **16** or hand **17** of the surgeon **14**, is inserted through the pad **35**, the material of the pad conforms to the surface of the instrument and forms the instrument seal with the instrument.

[0075] Accordingly, during the entire period beginning with insertion of the instrument and ending with withdrawal of the instrument, there is substantially no loss of insufflation gas through the pad **35a** nor any loss of pneumoperitoneum within the abdominal cavity **18**.

[0076] With further reference to **FIG. 7**, it will be appreciated that the arm **16** and hand **17** of the surgeon **14** are merely examples of instruments which can be inserted **20** through the access device **34a**. In the absence of the instrument, or hand **17** in the case of **FIG. 7**, the opening or slit **45a** merely closes against itself to form a zero seal, thus preventing the escape of insufflation gases through the access device **34a**. When the instrument, such as the hand **17**, is inserted through the opening or slit **45a**, an instrument seal is formed between the material of the access device **34a** and the exterior surface of the instrument. This prevents the escape of insufflation gases through the access device **34a**, even when an instrument is present. Thus, insufflation pressures can be maintained within the abdominal cavity **18** whether or not the instrument is in place. Note that these seals, the zero seal and the abdominal seal, can be formed as a single valve structure having properties for accommodating a full range of instrument sizes.

[0077] Formation of the pad **35a** will typically be accomplished in a simple molding process described in greater detail below. In such a process, the opening or slit **45a** may be formed as part of the molding process.

[0078] In most cases, the single access opening **45a** will be sufficient to accommodate the operative procedure. However, a further advantage of the access device **34a** will be particularly appreciated by the surgeon **14** who requires even more access through the pad **35a**. Consider for example, the surgeon **14** having his/her arm **16** inserted

through the opening **45a** when he/she decides that a further instrument is required for the operative procedure. Under these circumstances, a further opening through the pad **35a** can be established by merely inserting the desired operative instrument through the pad **35a**. In this manner, the instrument can create its own access hole beside the primary opening **45a**.

[0079] Particularly for those operative instruments having pointed distal ends, the instrument can merely be forced through the pad **35a** forming its own access hole, such as the opening **45a**, as it is moved distally. This opening, created by the operative instrument itself, would automatically form an instrument seal as the instrument is inserted, as well as a zero seal as the instrument is withdrawn.

[0080] For operative instruments not having pointed distal ends, it is possible to form a new access hole using a secondary instrument, such as a trocar obturator. After the access hole is formed, the obturator can be removed, vacating the access hole to receive the operative instrument. Throughout this process of initially forming an access hole and ultimately inserting an operative instrument through the hole, both zero seals and instrument seals are formed to maintain the pneumoperitoneum.

[0081] With the advantages associated with 1) the formation of an instrument seal and a zero seal with a single valve accommodating a wide range of diameters, and 2) the formation of an instrument opening using the instrument itself, it will be appreciated that the concept of this invention will typically be embodied with a structure that is particularly dependent upon the material which forms the access device **34**. In a preferred embodiment, the pad **35** is formed of a KRATON/oil mixture including a KRATON Tri-block with a Styrene-Ethylene/Butylene-Styrene (S-E/B-S) structure in combination with a mineral oil. Other tri-block polymers can be used for this application such as Styrene-Isoprene-Styrene, (S-I-S), Styrene-Butadiene-Styrene (S-B-S), Styrene-Ethylene/Propylene-Styrene (S-E/P-S) manufactured under the trademark SEPTON by the Kuraray Co. These general formulas can be further distinguished by the ratio of the styrene to rubber content: for example, Grade 1650 is a S-E/B-S tri-block with a 29/71 styrene to rubber ratio.

[0082] In addition to tri-blocks there are also di-block versions of these materials where styrene is present at only one end of the formula, for example, Styrene-Ethylene/Butylene (S-E/B) di-block.

[0083] The various base formulas may also be alloyed with one another to achieve a variety of intermediate properties. For example KRATON G1701X is a 70% S-E/B 30% S-E/B-S mixture with an overall Styrene to rubber ratio of 28/72. It can be appreciated that an almost infinite number of combinations, alloys, and Styrene to rubber ratios can be formulated, each capable of providing advantages to a particular embodiment of the invention. These advantages will typically include low durometer, high elongation, and good tear strength.

[0084] It is contemplated that the material of the pad **35** may also include silicone, soft urethanes and even harder plastics which might provide the desired sealing qualities with the addition of a foaming agent. The silicone materials can be of the types currently used for electronic encapsula-

tion. The harder plastics may include PVC, Isoprene, KRATON neat, and other KRATON/oil mixtures. In the KRATON/oil mixture, for example, oils such as vegetable oils, petroleum oils and silicone oils might be substituted for the mineral oil. In the broadest sense, all of these mixtures can be described generally as a gel. The gel will typically have properties including an ability to "flow" which approaches that of a fluid. Particularly in the vicinity of any opening or slit **45** extending through the access device **34**, propagation of the opening may be of concern. Stresses resulting from the presence of an instrument will be concentrated at the ends of such an opening or slit. For this reason, a good tear resistance is desired for the gel material. Such a tear resistance is often inherent in the KRATON/oil mixtures and may be enhanced by encapsulating the gel in other materials. For example, a low tear resistant gel could be encapsulated in a urethane sheath to improve the tear resistant qualities of the resulting products. Such a sheath need not be elastic but could be comprised, for example, of overlapping sheets of a non-elastic material.

[0085] Any of the gel materials contemplated could be modified to achieve different properties such as enhanced lubricity, appearance, and wound protection, or to provide anticancer or anti-microbial activity. Additives can be incorporated directly into the gel, for example in the case of pharmaceuticals, or applied as a surface treatment to the gel, for example, to improve lubricity or appearance. Other compounds could be added to the gel to modify its physical properties or to assist in subsequent modification of the surface by providing bonding sites or a surface charge. Antioxidants and antirads can be added to the mixture to extend the shelf life of the finished product or increase its ability to withstand radiation sterilization.

[0086] Sealing materials used in medical access devices of the past have been chosen primarily for their durometer and elongation. It is these properties which measure the ability of the material to move into small spaces and crevices as may be required to form, an instrument seal across the working channel of a trocar. For example, in the past, a silicone mixture was used in medical valves. This mixture had the following properties: an ultimate elongation less than about 1000 percent and a durometer not less than about 5 Shore A.

[0087] These properties of the prior art materials are far exceeded by the properties associated with the present invention which in some respects provide a full magnitude of advantage. In fact, the difference between the materials of the prior art and the materials of the present invention are sufficiently substantial, that it is perhaps misleading to refer to the present material as merely a gel. According, the material of the present invention, having properties including an ultimate elongation greater than about 1000 percent and a durometer less than about 5 Shore A, will be referred to herein as an "ultragel."

[0088] In a preferred embodiment of the present invention, the ultragel includes KRATON and mineral oil and provides a sealing material with the following properties: an ultimate elongation exceeding about 1500 percent, and a durometer of less than about 200 Bloom. The durometer in this case is considerably lower than that of the prior art materials. In fact, the durometer of the present material is so soft it cannot even be measured on the Shore A scale.

[0089] The resulting elongation and durometer of the present material facilitates its use with as an access valve which is capable of forming seals with a full range of instrument sizes, but is also capable of functioning as a zero seal. Whereas access devices of the prior art may have required as many as six separate seals in order to accommodate a full range of instrument sizes, access devices can now be made with only a single valve formed of the ultragel material.

[0090] In a typical manufacturing process, the KRATON G1651 is mixed with the mineral oil in a ratio by weight of 1 to 9. In order to manufacture this material, the combination is heated to a temperature of about 200° centigrade. In a preferred method of manufacturing, the mold is provided with a circumferential ring insert which is molded into the gel, and slit inserts which can be removed from the gel to form the opening or slit **45**. The resulting gel can be coated with cornstarch to reduce tack and cooled at room temperature.

[0091] Many of the properties of the KRATON/oil mixture will vary with adjustments in the weight ratio of the components. In general, the greater the percentage of mineral oil, the more fluid the mixture; the greater the percentage of KRATON, the more rigid the material. Weight ratios of KRATON to oil as low as 1 to 5 have been contemplated for a more rigid structure. As the KRATON/oil weight ratio approaches 1 to 10, the mixture becomes more liquid. Ratios as high as 1 to 15 have been contemplated for this invention.

[0092] The processing temperature can also vary considerably as it is primarily dependent on the type of KRATON used. Temperatures in a range of about 150° centigrade to about 250° centigrade have been contemplated.

[0093] With an appreciation that these ratios and temperatures can develop considerably different properties, it is now apparent that these materials can be layered to provide generally different properties within each layer. For example, an outer layer might be formed of a KRATON/oil mixture having more rigid properties, thereby providing the pad **35** with an outer lave, that is more rigid. After that layer is at least, partially cured, another layer of the material can be poured inside of the outer layer. This second layer might be softer providing the pad **35** with the significant sealing properties. It has been found that successive layers will tend to fuse slightly at their interface, but will generally maintain their separate identities. Additional layers could be added to provide a progression of properties in a particular device.

[0094] Having discussed the properties desirable for the gel material, and the process of manufacture, one can now address the other embodiments of the concept which may provide additional advantages for particular surgical procedures. An embodiment of the access device **34**, shown in its operative position in **FIG. 6**, is illustrated by itself in the axial cross section view of **FIG. 8**.

[0095] This same embodiment can be reinforced with o-rings **61** and **63** as illustrated in **FIG. 9** where elements of structure are designated by the same reference number followed by the lower case letter "b." Providing these O-rings **61** and **63** may facilitate several functions associates with the access device **34b**. For example, the rings **61**, **63** will typically aid in maintaining a radial sealing pressure on all sides of the opening **45b**. The rings **61** and **63** will also

tend to maintain the flanges **54b** and **56b** respectively, in their generally planar configurations. This further ensures that the flanges **54**, **56** will not collapse into the incision **32** with the insertion or withdrawal of an instrument, such as the surgeon's hand **17**. Of course, the O-rings **61** and **63** must be sufficiently large to accommodate the instrument during insertion and removal.

[0096] A further embodiment of the invention is illustrated in **FIG. 10**, where elements of structure are similar to those previously disclosed are designated with the same reference numerals followed by the lower case letter "c." This embodiment includes the pad **35c** with the opening or slit **45c**. The external perimeter o-ring **61c** is inserted molded into the circumference of the pad **35c**. The internal o-ring **63c** is coupled to the pad **35c**, for example, by way of attachment to the o-ring **61c** for example, by a membrane **65**. In this case, the membrane **65** has a generally cylindrical configuration and elastomeric properties. In preferred embodiments, the membrane **65** is formed of urethane, neoprene or isoprene.

[0097] When the embodiment of **FIG. 10** is being operatively positioned, the internal o-ring **63b** is initially gathered and inserted through the incision **32** (**FIG. 2**). The pad **35c** and external o-ring **61c** are left outside the incision **32** so that the only material extending across the incision **32** is the membrane **65**. It will be noted that in this case, the working channel **36c** is formed by the slit **45c**, the cylindrical membrane **65**, and the internal o-ring **63b**.

[0098] In this particular embodiment, the pad **35c** functions generally as described with reference to **FIG. 2**. The primary seal between the pad **35c** and the abdominal wall **21** can be formed either with a circumferential ring, such as the adhesive ring **52c**, or by relying on the sealing characteristics of the insufflation **2as** against the internal o-ring **63b** and membrane **65**.

[0099] This embodiment of **FIG. 10** is of particular advantage as it incorporates the pad **35c** in perhaps its simplest configuration, while providing a primary seal between the device **34c** and the abdominal wall **21** which is facilitated by the insufflation pressure. Furthermore, the membrane **65** enhances the sealing characteristics of the device **34c**, and provides a lining for the incision **32**. With the membrane **65**, the incision **32** need not be stretched to a diameter greater than that required by any instrument inserted through the work-in, channel **36c**.

[0100] A further embodiment of the invention is illustrated in **FIG. 11** where elements of structure similar to those previously disclosed are designated with the same reference numeral followed by the lower case letter "d." This embodiment is similar to that of **FIG. 8** in that it includes the pad **35b**, slit **45d**, exterior flange **54d**, and internal flange **56d**. The embodiment of **FIG. 11** differs from that of **FIG. 8** in that it includes a lead-in cavity **70** which is in communication with the slit **45d**.

[0101] In a preferred embodiment, this cavity **70** is sized and configured to **18** receive the arm **16** of the surgeon **11** in a manner illustrated in **FIG. 7**. In this case, the slit **45d** would function primarily to maintain a zero seal, while the portions of the pad **35d** or flange **54d** which form the cavity **70** would function primarily to form the instrument seal.

[0102] A further embodiment of the invention is illustrated in the plan view of **FIG. 12** and the cross section views of

FIGS. 13 and 14. In this embodiment, elements of structure similar to those previously discussed are designated with the same reference numeral followed by the lower case letter "e." In this case, the lead-in cavity has the general shape of a cylinder **72** with an axis that is collinear with the axis **47e** of the pad **35e**.

[0103] As perhaps best illustrated in **FIG. 13**, the slit **45e** has a trapezoidal configuration. Thus, it begins proximally with a narrow length which may generally be equivalent to the diameter of the cylinder **32**. From the cavity **70e**, the length of the slit **45e** increases with progressive positions distally through the pad **35e**. In the illustrated embodiment, the trapezoidal slit **45e** is formed as the frustum of an isosceles triangle.

[0104] A further embodiment of the invention is illustrated in **FIGS. 15 and 16** wherein elements of structure similar to those previously described are designated with the same reference numeral followed by the lower case letter "f." As previously discussed with reference to **FIG. 11**, this embodiment of the pad **35f** is formed with a proximal surface **71** and a distal surface **73**. The pad **35f** also includes the coaxial lead-in cylinder **72f** and the trapezoidal slit **45f**. However, in this case, a duck-bill valve **74f** is provided to further enhance the characteristics of the zero seal. As illustrated, the working channel **36f** is formed by the lead-in cavity **70f**, the slit **45f**, and an extension of the slit **45f** which is defined by the duck-bill valve **74f**. The duck-bill valve **72** can be formed with opposing flanges **76** and **78** which extend distally of the distal surface **73**. When operatively disposed, the pad **35f** can be positioned with its distal surface **73** against the exterior surface of the abdominal wall **21** (**FIG. 2**) and with the flanges **76** and **78** extending into the incision **32**. With this configuration and operative disposition, the abdominal wall **21** at the incision **32** will produce opposing forces on the flanges **76** and **78** which tend to close the slit **45f**, particularly in the absence of an instrument. In this manner, the duck-bill valve **74** can be relied on to enhance the characteristics of the zero seal.

[0105] A further embodiment of the invention is illustrated in **FIGS. 17 and 18** wherein elements of structure similar to those previously discussed are designated by the same reference numeral followed by the lower case letter "g." In this embodiment of the access device **34g**, the pad **35g** can be formed generally as discussed with reference to **FIG. 13**. In this embodiment, however, the pad **35g** can be enclosed along its sides and the distal surface **73g**, by a base **81**. In this case, the pad **35** might be formed by the highly elastic material previously discussed, while the base **81** might be formed of a more rigid but nevertheless flexible material such as a urethane. With this configuration, the duck-bill valve **74f** would be structured to extend distally of a distal surface **83** associated with the base **81**. This would enable the duck-bill valve **74f** to be formed of the base material rather than the superelastic material. This might also improve the zero seal characteristics for particular operative applications.

[0106] Another simplified form of the invention is illustrated in **FIGS. 19 and 20**, where elements of structure similar to those previously discussed or designated with the same reference numeral followed by the lower case letter "h." The lead-in cavity **78h**, in this case, is formed as an inverted cone **77** having its base at the proximal surface **71h**

and its apex in proximity to the distal surface **73h**. Thus, the lead-in cavity **70h** has an area in radial cross section which decreases with progressive positions distally through the pad **35h**. In this embodiment, the proximal regions near the base of the cone **87** form the instrument seal, while the distal regions at the apex of the cone form the zero seal. The conical configuration of the lead-in cavity **70h** also tends to funnel an instrument into the opening **45h** leading distally to the apex of the cone **87**.

[0107] It will be appreciated generally, that the slit **45** and lead-in cavity **70** can be provided with many different individual and cooperative configurations. By way of example, perhaps the simplest form for the pad **35** is illustrated in the embodiment of **FIGS. 21 and 22** wherein elements of structure similar to those previously described are designated by the same reference numeral followed by the lower case letter "j." In this embodiment, the pad **35j** with its proximal surface **71j** and distal surface **73j**, is provided with a simple trapezoidal slit **45j**. In this case, the slit **45j** extends between the proximal surface **71j** and the distal surface **73j**.

[0108] The slit **45j** in this embodiment of **FIG. 21** is typical of many structures which will define the slit **45j** with a planar configuration. In such a case, the portions of the pad **35j** which form the slit will comprise opposing planar surfaces such as those designated by the reference numerals **90** and **92** in **FIG. 22**.

[0109] It will be apparent that the slit **45** need not be formed by opposing surfaces having a planar configuration. Nevertheless, these opposing surfaces need to be capable of coming into sealing contact with each other in order to establish the zero seal. Other slit configurations capable of accomplishing this function, may offer further advantages in particular procedures. Other examples of slit configurations are illustrated merely by way of example in **FIGS. 23-26**.

[0110] The embodiment of **FIG. 23** is similar to that of **FIG. 22** in that the opening **45j** comprises a single slit which extends from the proximal surface **71j** to the distal surface **73j**. In the case of the **FIG. 22** embodiment, the axis **47j** is disposed within the plane of the slit **45j**. In the case of the **FIG. 23** embodiment, the plane of the slit **45j** does not include the axis **47j**. Rather, the slit **45j** is formed in a plane which has an angular relationship with the axis **47j**, the proximal surface **71j**, as well as the distal surface **73j**. This construction enables the slit **45j** to have a length greater than the thickness of the pad **35j**.

[0111] In the embodiment of **FIG. 24**, elements of structure similar to those previously discussed are designated with the same reference numeral followed by the lower case letter "k." In this case, the opening **45k** is configured as two slits **94** and **96** formed in individual planes that are angularly spaced with respect to each other. Of course, two or more of the planar slit **94** and **96** may be equally angularly spaced around the axis **47k**. In one embodiment, the individual planar slits **94** and **96** intersect at the axis **47k**. Alternatively, the slits **94** and **96** may be axially spaced in order to facilitate formation of the instrument seal.

[0112] In the embodiment of **FIG. 25**, elements of structure similar to those previously discussed are designated with the same reference numeral followed by the lower case letter "m." In this embodiment, the opening **45m** is defined

as a slit **98** having a curved rather than planar configuration. In the illustrated embodiment the curved slit **98** is formed as a spiral around the axis **47m**. Along the axis **47m**, the opposing surfaces forming the spiral slit **98** can "flow" into sealing proximity in order to produce the zero seal.

[0113] **FIG. 26** illustrates a similar embodiment including a spiral slit. In this figure, elements of structure similar to those previously discussed are designated by the same reference numeral followed by the lower case letter "n." The spiral slit **98n** in this embodiment is also formed around the axis **47n** of the pad **35n**, but in this case the portions forming the slit **98n** do not extend completely to the axis **47n**. As a result, an axial channel **100** is formed at least, partially along the axis **47n**. This channel **100** can function in a manner similar to the lead-in cavity **70** discussed with reference to **FIGS. 11-12**. This channel **100** can even be formed with a conical configuration similar to that discussed with reference to **FIG. 19**.

[0114] In an embodiment where the channel **100** is left open, a zero seal might be provided by positioning a septum valve across the channel **100**. Such an embodiment is illustrated in **FIG. 27**, wherein the septum valve is designated with a reference numeral **101** and the other elements of structure similar to those previously discussed are designated with the same reference numerals followed by the lower case letter "p." Thus the embodiment of **FIG. 27** includes the spiral slit **98p**, the pad **35p**, and the axis **47p**. This embodiment of **FIG. 27** is merely representative of many other embodiments that will combine a slit, such as the slit **98p**, with other valve structures, such as the septum valve **101**.

[0115] Other curved slit configurations would include embodiments wherein the slit is curved, sinusoidal, or S-shaped in a side elevation view. Such configurations provide a slit part having a length greater than the thickness of the pad. Normally, the more circuitous the slit path, the better the sealing characteristics.

[0116] A further and more complex configuration for the opening **45** is illustrated in the embodiment of **FIG. 28** wherein elements of structure similar to those previously disclosed are designated with the same reference numeral followed by the lower case letter "q." This embodiment is representative of many other complex embodiments which can be formed with intricate shapes and different materials in order to accomplish the desirable function of forming, with a single valve, a zero seal as well as an instrument capable of accommodating a full range of instrument sizes. In the embodiment of **FIG. 28**, the pad **35q** is formed with a base **110** which is disposed circumferentially of a core **112**. In this case, the core **112** is formed of the superelastic material or gel and provided with the shape of the cone **87q** as discussed with reference to **FIGS. 19 and 20**. The base **110** is formed from a material that may not be elastic, but preferably is flexible. In the preferred embodiment, the base **110** is formed of a urethane.

[0117] In this construction, the base **110** is provided with a plurality of spokes **114** each of which extends radially inwardly from a base **116** to a tip **118**. The core **112** extends from the axis **47q** outwardly to the tips **118** of the spokes **114**. In the illustrated embodiment, the core **112** has fingers **121** which extend beyond the tips **118** and toward the bases **116** between each adjacent pair of the spokes **114**. These

fingers 121 extend radially outwardly to an end surface 123 which stops short of the base 116 leaving a void 125 therebetween.

[0118] The voids 125 are of particular interest to this embodiment and can be incorporated into any of the embodiments previously discussed. Such voids 125 provide a space or absence of material into which the highly elastic material, such as that of the fingers 121, can expand during insertion of an instrument such as the arm 16 (FIG. 7). Since the gel material is almost fluid in its properties, the voids 125 permit expansion of the gel with very little resistance. Voids, such as the voids 125 in the embodiment of FIG. 28, can be defined solely in the gel material or between the gel material and any other base material.

[0119] In the case of FIG. 2S, the spokes 114 and fingers 121 are defined generally in planes which are parallel to the axis 47q. Similar fingers, illustrated in the embodiment of FIG. 31 are defined generally in a plane which is perpendicular to the axis. In this embodiment, elements of structure similar to those previously disclosed are designated by the same reference numeral followed by the lower case letter "r." As illustrated, the pad 35r can be formed with a relatively large opening 45r having the configuration of a coaxial cylinder 130. A plurality of fingers or flaps 132 extend into the opening 45r and tend to form a lead-in cavity 70r with properties such as those discussed with reference to FIG. 19. In this case, the annular flaps 132 have a conical configuration extending from a base 134 to an apex 136. It will be noted that the areas between the flaps 132, form voids 125r into which the flaps 132 can be displaced upon insertion of an instrument, such as the arm 16.

[0120] A further embodiment of the invention is illustrated in FIG. 32 where elements of structure similar to those previously disclosed are designated with the same reference numeral followed by the lower case letter "s." This exploded view of the access device 34s includes not only the pad 35s but also a complimentary structure for maintaining the position of the pad 35s, for forming a seal between the pad 35s and the abdominal wall 21, and for dilating the incision 32 to a variable extent as required by the surgeon 14. In this case, the access device 34s includes three components, a jell cap 143, base 145, and a retraction sheath 147.

[0121] The gel cap 143 includes not only the gel pad 35s, but also a circumferential can ring 154 which can be inserted and molded to the pad 35s. The resulting gel cap 143 forms a seal with the base 145, thereby defining a the working channel 36s through the pad 35s, the cap ring 154, the base 145, and the retraction sheath 147. In the manner previously discussed, this working channel 36s includes the single valve formed by the gel pad 35s which provides both a zero seal and an instrument seal for a wide range of instrument diameters.

[0122] The structure associated with the gel pad 143 is described in greater detail with reference to FIGS. 33 and 34. In the plan view of FIG. 33, it can be seen that this embodiment includes the gel pad 35s centrally disposed within the circumferential cap ring 154. Holding tabs 156 can be provided to extend radially outwardly of the can ring 154. These holding tabs 156 can facilitate the sealing engagement of the gel cap 143 with the base 145 in the manner described in greater detail below.

[0123] The gel pad 35s can be formed of any of the materials previously discussed although the preferred

embodiment includes the KRATON/mineral oil gel. The cap ring 154 for such an embodiment can be advantageously formed of KRATON only. This will make the cap ring 154 more rigid than the gel pad 35s while maintaining an excellent material interface between the pad 35s and the ring 154. In a typical manufacturing operation, the cap ring will be pre-disposed in the mold for the gel pad 35s with the unitary structure of the gel cap 143 resulting.

[0124] The cross section view of FIG. 34 shows the gel cap 143s and illustrates an annular void 158 formed on the inner circumference of the cap ring 154. This void 158 is of particular advantage in forming a sealing relationship with the base 145 in the manner discussed in greater detail below.

[0125] The base 145 of this embodiment is shown in greater detail in the plan and cross section of views of FIGS. 34 and 35, respectively. From these views it will be noted that the base 145 can be provided with a smooth generally cylindrical inner surface 161 which extends proximally to a rounded end surface 163 and outwardly from the end surface 163 along an annular lip 165. A plurality of tabs 167 can be equally spaced to extend outwardly and distally around the circumference of the lip 165.

[0126] Distally of the inner surface 163, an annular flange 170 can be provided with an annular projection 172 sized and configured to form the desired sealing relationship between the gel can 143 and the base 145. The process of molding the base 145 can be facilitated by forming the base as two separate components divided, for example, by a dotted line 174 in FIG. 35. In a preferred embodiment, the base 145 is molded from a polycarbonate material.

[0127] A preferred embodiment of the retracting sheath 147 is illustrated in FIG. 37. In this view it can be seen that the retraction sheath 147 includes a tubular wall 175 which has the configuration of the frustum of a cone 176 at its distal end and the configuration of a cylinder 177 at its proximal end. A flexible retaining ring 152 terminates the distal end while a fold 154' is formed at the proximal end. The tubular wall 175 is illustrated to include an outer surface ISO and an inner surface 181. In a preferred embodiment, the sheath 147 is formed of an elastomer, such as neoprene, so its frustule conical and cylindrical configurations exist primarily in the natural unstretched state.

[0128] As the sheath 147 is stretched axially, the diameter of the cylindrical proximal end increases thereby placing radial forces on the incision 32. The more the sheath 147 is stretched axially, the greater becomes the diameter of the sheath and consequently the larger becomes the opening through the incision 32. This feature is of particular advantage as it permits the surgeon to define the size of the incision 32 with an appropriate degree of axial tension on the sheath 147. By maintaining this tension, the preferred size of the incision 32 is maintained throughout the operation. In a preferred apparatus and method, the axial tension is maintained by stretching the sheath 147 over the tabs 167 (FIG. 34) of the base 145. Indicia 182 can be printed on the sheath 147 to provide an indication of the relationship between the axial stretch of the sheath 147 and the size of the incision 32.

[0129] The fold 153 is provided to facilitate a grip on the proximal end of the sheath 147. This fold 153 can also function to provide reinforcement where the walls of the

sheath 147 engage the tabs 167 of the base 145. In the embodiment illustrated in FIG. 38 additional folds 184, 186 are provided at spaced axial locations, such as those defined by the indicia 182 in FIG. 37. With these folds 184 and 186, additional points of reinforcement are provided to engage the tabs 167 while providing the sheath 147 with predetermined degrees of axial stretch associated with different sizes of the incision 32. The method of using the embodiment of FIG. 32 is illustrated the progressive use of FIGS. 39-42. In FIG. 39, a top plan view of the abdominal wall 21 of the patient 10 is illustrated with a template 195 positioned to facilitate location of the incision 32. The size of the incision 32 can be determined with the indicia 182 on the template 195 showing, for example, multiple lengths of a line 197, each length being equated with a glove size for the surgeon's hand 17 (FIG. 7). Knowing his/her glove size, the surgeon will merely cut the incision in accordance with an appropriate length of the line 197. The longer lengths of the line 197 are associated with the larger incisions, the larger glove sizes and accordingly the larger hands 17. After the incision 32 has been cut along the line 197, the template 195 can be removed.

[0130] As illustrated in FIG. 40, the retraction sheath 147 can then be mounted through the incision 32. Initially the ring 152 is compressed and fed through the incision 32. On the inner surface of the abdominal wall 21, the ring 152 is free to expand to its larger diameter, as shown by a dotted line 158 in FIG. 40. The portions of the wall 176 which define the cylinder 177 are left to extend proximally through the opening 32 as shown in FIG. 40.

[0131] Prior to or after inserting the sheath 147, the base 145 can be disposed around the incision 32. Then the exposed portions of the sheath 147 will extend through the incision 32 and within the circumferential base 145. As illustrated in FIG. 41, the wall 176 of the sheath 147 can then be drawn proximally, outwardly of the page in FIG. 41, to axially stretch the sheath 147. As noted, when the sheath 147 is axially stretched, it will create radial forces on the abdominal wall 21 which will tend to enlarge the incision 32. The greater the axial stretch, the larger the incision 32.

[0132] When the incision 32 has the desired size, the stretched sheath 147 can be drawn over the tabs 167 to maintain the axial stretch and the desired size for the incision 32. Either the indicia 182, as shown in FIG. 36, or the additional folds 184 and 186 as shown in FIG. 37, can be aligned with the tabs 167 to provide a predetermined size for the incision 32. At this point, the seal between the abdominal wall 21, the sheath 147, and the base 145 is fully established.

[0133] A final step remaining in this process is the attachment of the gel cap 143 to the base 145. This is accomplished as illustrated in FIG. 36 by capturing the lip 172 of the base 145 in the annular void 158 of the gel cap 143. Bending the holding tabs 156 upwardly and outwardly facilitates this engagement which ultimately forms a seal between the base 145 and the gel cap 143.

[0134] Although this invention has been disclosed with reference to certain structural configurations, it will be appreciated that these products are merely representative of many different embodiments of the invention. Accordingly, one is cautioned not to limit the concept only to the disclosed embodiments, but rather encouraged to determine the scope of the invention only with reference to the following claims.

1. A surgical access device adapted for disposition relative to an incision in a patient, the access device facilitating insertion of a hand of the surgeon through the access device and maintenance of a sealing relationship with an arm of the surgeon, comprising:

a valve including a gel material having portions defining an access channel;

the access channel having a length not less than about one-quarter inch and extending into communication with the incision in the patient; and

the gel material including an elastomer.

2. The surgical access device recited in claim 1, wherein the elastomer includes a silicone.

3. The surgical access device recited in claim 1, wherein the elastomer includes a urethane.

4. The surgical access device recited in claim 3, further comprising a foaming agent forming with the urethane a foam gel.

5. The surgical access device recited in claim 1, wherein the gel includes at least one of a urethane, polyvinylchloride, Isoprene, Kraton an oil, and a foaming agent.

6. The surgical access device recited in claim 1, wherein the elastomer includes:

a base; and

an oil forming with the base an elastomeric oil mixture.

7. The surgical access device recited in claim 6, wherein the oil includes at least one of:

a vegetable oil, a petroleum oil, and a silicone oil.

8. A surgical access device facilitating insertion of a surgeon's hand through the hand port in a sealing relationship with the surgeon's arm during laparoscopic surgery through an incision in an abdominal wall of a patient, the access device comprising:

a valve structure forming a pad adapted to be disposed over the incision and to form a seal around the incision;

the pad including a gel material having portions defining an access channel through the pad and extending into communication with the incision in the patient, the gel material providing the pad with properties including lubricity, appearance wound treatment, anti-cancer protection, and antimicrobial protection; and

an additive disposed relative to the gel material and having properties for modifying at least one of the properties of lubricity, appearance, wound treatment, anti-cancer protection, and antimicrobial protection, of the pad.

9. The surgical access device recited in claim 8, wherein the additive includes at least one of a powder, cornstarch and a fine particulate.

10. The surgical access device recited in claim 9, wherein the additive is disposed on the elastomer as a surface treatment.

11. The surgical access device recited in claim 8, wherein the additive is a mechanical device disposed in the elastomer.

12. A surgical access device facilitating a sealing relationship Edith an instrument extending through the device and into an incision into a body wall of the patient, the access device comprising:

- a valve structure disposed relative to the incision in a sealing relationship with the body wall around the incision;
- a valve included in the valve structure and disposed relative to the incision in the body wall;
- the valve having a first state in the absence of an instrument extending through the valve structure, and a second state in the presence of an instrument extending through the valve structure;
- the single valve in the first state forming a zero seal in the absence of the instrument extending through the valve structure; and the valve in the second state forming a seal with the instrument in the presence of the instrument extending through the access device
- 13.** The surgical access device recited in claim 12, further comprising:
- an external flange extending radially outwardly of the valve structure and adapted for disposition exteriorly of the body wall.
- 14.** The surgical access device recited in claim 13, further comprising:
- an interior flange extending radially outwardly of the valve structure and adaptive for operative disposition interiorly of the body wall.
- 15.** The surgical access device recited in claim 14, wherein the access device in radial cross section has the general configuration of the letter "H".
- 16.** The surgical access device recited in claim 12, wherein:
- the valve is a first valve including portions defining a slit; and
- the valve structure further comprises a second valve having a duckbill configuration and being disposed distally at the first valve.
- 17.** The surgical access device recited in claim 14, further comprising:
- at least one support ring disposed in at least one of the interior flange and the exterior flange.
- 18.** The surgical hand port recited in claim 14, wherein:
- the interior flange has a first thickness;
- the exterior flange has a second thickness greater than the first thickness of the interior flange
- 19.** The surgical access device recited in claim 12, wherein the instrument comprises an arm of a surgeon.
- 20.** A medical access device, including:
- a tubular member having an elongate configuration;
- at least one wall defining with the tubular member a working channel sized and configured to receive an instrument; and
- an ultragel disposed in the working channel and being adapted to form a seal with any instrument disposed in the working channel
- 21.** The medical access device recited in claim 20, wherein:
- the ultragel has properties including any elongation of not less than about 1200 percent a durometer measurable on the Shore A scale.
- 22.** The medical access device recited in claim 21, wherein:
- the ultragel has properties including an elongation not less than about 1500 percent, a durometer of not greater than 200 Bloom.
- 23.** A surgical hand port facilitating a sealing relationship with a surgeon's arm extending through the hand port and into an incision in an abdominal wall of a patient, the hand port comprising:
- a valve structure comprising only a single valve disposed relative to the incision in the abdominal wall, the single valve having a first state in the absence of the arm of the surgeon extending through the valve structure, and a second state in the presence of the arm of the surgeon extending through the valve structure;
- means for coupling the valve structure to the abdominal wall in a sealing relationship with the abdominal wall around the incision;
- the single valve in the first state forming a zero seal in the absence of the arm of the surgeon extending through the valve structure; and
- the single valve structure in the second state forming an arm seal with the arm of the surgeon in the presence of the arm of the surgeon extending through the hand port.
- 24.** The surgical hand port recited in claim 23, wherein the valve structure further comprises:
- a gel;
- portions of the gel, at least partially defining an opening through the valve structure; and
- the opening defining portions of the gel having properties in the first state for sealing the opening in the absence of the arm of the surgeon extending through the opening.
- 25.** The surgical hand port recited in claim 24, wherein the opening defining portions of the gel define the opening in the shape of at least one slit.
- 26.** The surgical hand port recited in claim 25, wherein:
- the valve structure is disposed generally in a first plane; and
- the slit is defined in a second plane generally non-perpendicular to the first plane.
- 27.** The surgical hand port recited in claim 25, wherein:
- the valve structure is disposed generally in a first plane; and
- the slit is defined in a second plane generally perpendicular to the first plane
- 28.** The surgical hand port recited in claim 24, wherein the opening defining portions define the opening with a spiral configuration.
- 29.** The surgical hand port recited in claim 24, wherein the opening defining portions define the opening with at least one pair of mating flappers
- 30.** The surgical hand port recited in claim 24, wherein:
- the valve structure has an axis;
- the opening defining portions define the openings generally as a line in radial cross section; and

the length of the line increases with progressive positions distally along the axis of the valve structure.

31. The surgical hand port recited in claim 23, wherein the zero seal and the arm seal have properties for inhibiting the escape of liquids and eases through the single seal.

32. The surgical hand port recited in claim 24, wherein the gel includes:

an elastomer; and a foaming agent

33. The surgical hand port recited in claim 24, wherein the gel includes silicone

34. The surgical hand port recited in claim 24, wherein the gel includes an oil.

35. The surgical hand port recited in claim 23, wherein the coupling means includes an adhesive having properties for attaching the valve structure to the abdominal wall.

36. The surgical hand port recited in claim 24, further comprising:

at least one support ring disposed circumferentially of the valve structure to reinforce the single valve of the valve structure.

37. The surgical hand port recited in claim 24, wherein the gel is a thermoplastic elastomer

38. The surgical hand port recited in claim 28, further comprising a septum seal disposed across the spiral opening.

39. The surgical hand port recited in claim 24, wherein the gel is a thermoset elastomer

40. A surgical hand port facilitating insertion of a surgeon's hand through the hand port in a sealing relationship with the surgeon's arm during laparoscopic surgery through an incision in an abdominal wall of a patient, the hand port comprising:

a valve structure coupled to the abdominal wall in a sealing relationship with the abdominal wall around the incision;

the valve structure being disposed relative to the incision and forming with the incision an access channel, the valve structure having a first state in the absence of the arm of the surgeon extending through the valve structure and a second state in the presence of the arm of the surgeon extending through the valve structure;

the valve structure in the first state having properties for forming a gas seal with itself along the access channel;

the valve structure in the second state forming a gas seal with the arm of the surgeon extending through the hand port; and

first portions of the valve structure including a gel defining an opening through the valve structure to receive the arm of the surgeon;

41. The surgical hand port recited in claim 40, further comprising,

second portions of the valve structure defining a proximal cavity communicating with the opening defined by the first portions of the valve structure.

42. The surgical hand port recited in claim 41, wherein the cavity in radial cross section has the shape of a rectangle.

43. The surgical hand port recited in claim 41, wherein the cavity in radial cross section has the shape of a trapezoid.

44. The surgical hand port recited in claim 41, wherein: the valve structure has an axis; and

the first portions of the gel define the opening along the axis.

45. The surgical hand port recited in claim 44, wherein the second portions of the gel include side walls which converge with progressive distal positions along the axis

46. The surgical hand port recited in claim 42, wherein the cavity has the shape of a cylinder.

47. The surgical hand port recited in claim 41, wherein the gel is a first gel and the valve structure further comprises:

a second gel disposed radially outwardly of the first portions of the first gel defining a the opening; and

the second gel being more rigid than the first gel in order to reinforce the first gel defining the opening.

48. The surgical hand port recited in claim 40, wherein the gel includes an elastomer and an oil.

49. A surgical hand port facilitating insertion of a hand of a surgeon through the hand port in a sealing relationship with an arm of the surgeon during laparoscopic surgery through an incision in an abdominal wall of a patient the hand port comprising:

a valve structure disposed over the incision and forming a seal around the incision.

a valve included in the valve structure, the valve being formed of a gel material including portions defining a sealable opening providing access to the incision;

the gel material having properties for sealing the opening in the absence of any object extending through the opening, and for sealing the opening around the arm of the surgeon extending through the opening; and

the gel material including an elastomeric oil mixture.

50. The surgical access device recited in claim 49, wherein the elastomeric oil mixture has properties including an elongation greater than about 1000 percent.

51. The surgical access device recited in claim 9, wherein the elastomeric oil mixture has a durometer less than about 5 Shore A.

52. A method for making a surgical access device adapted for use in providing sealable access for an instrument extending through the access device and an incision in the body wall of a patient, comprising the steps of:

providing a gelling agent;

mixing the gelling agent with an oil to form an oil gel;

molding the oil gel into the configuration of a pad sized and shaped for disposition relative to the incision in the body wall; and

creating an opening through the pad to provide sealable access for the instrument to extend through the pad and the incision in the body wall.

53. The method recited in claim 52, farther comprising the steps of:

providing an additive having at least one of the properties for radiation absorption, detoxification, detackification and anti-oxidation; and

during the mixing step, combining the additive with the oil gel.

54. The method recited in claim 53, wherein the combining step includes the step of applying the additive to the oil gel as a surface treatment.

55. The method recited in claim 52, where the molding step includes the step of embedding hardware in the oil gel.

56. The method recited in claim 52, wherein the creating step includes the step of:

placing an insert into the oil gel prior to the molding step;
and

removing the insert from the oil gel to create the opening

57. A method for using a eel seal in a surgical procedure for operating on an organ contained in a body cavity defined by a body wall, comprising the steps of:

providing the gel seal in the form of a pad having a slit extending through the pad;

creating an incision in the body wall;

placing the pad relative to the incision to create a first seal around the incision the slit communicating with the incision and forming a second seal relative to the incision;

removing at least a portion of the organ from the body cavity through the incision in the body wall and the slit in the pad;

during the removing step forming the second seal with the organ;

operating on the organ exteriorly of the body cavity; and

returning the organ to the body cavity through the slit in the pad and the incision in the body wall.

58. The method recited in claim 57, wherein the removing step includes the steps of:

inserting a hand through the slit in the pad and the incision in the body wall;

grasping the organ interiorly of the body cavity; and

withdrawing the hand and the organ through the incision in the body wall and the slit in the pad.

59. The method recited in claim 57, wherein the first seal and the second seal are gas seals inhibiting the escape of air from the body cavity through the pad.

60. The method recited in claim 57, wherein the providing step includes the step of forming the gel seal of an oil gel material.

61. A method for using an access device to provide instruments access through an opening in a body wall and into a body cavity comprising:

providing a pad of gel material with portions free of any opening through the pad;

sealing the pad to the body wall around the incision inserting the instrument, at least partially, through the portions of the pad to form an opening through the gel material;

forming an instrument seal between the gel and the instrument when the instrument is positioned through the pad; and forming a zero seal at the opening when the instrument is not positioned through the pad.

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摘要(译)

外科进入装置包括单个阀，其与主体壁形成密封并且提供进入体腔的进入通道。该阀具有在没有仪器的情况下产生零密封的特性，以及具有全范围仪器直径的仪器的仪器密封。该阀可以包括凝胶，并且优选地是由弹性体和油提供的超凝胶，其提供大于1000%的伸长率和小于5邵氏A的硬度。岸阀可以用作手持端口，其中该器械包括外科医生的手臂从而提供进入腔体的手。制造外科进入装置的方法包括组合或胶凝剂与油，优选在模制过程中。使用该装置的方法包括用仪器产生开口的步骤。在特定的过程中，器官可以通

过单个瓣膜从体腔移除以产生器官密封，同时器官在体腔外部被寻址。
该瓣膜和方法特别适用于腹腔镜手术，其中腹腔用气体吹入，从而需要在各种手术中进行零密封，器械密封和器官密封。

